POWER

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The Pursuit of Happiness

ON HIS RETURN from a four months' visit to America, J. B. Priestly, English novelist, comments, as so many have done before him, upon the failure of our mode of living to develop the cultural, the soul-satisfying and spiritual contentment side of life.

We have, he says, an extraordinary material civilization, with its amazing efficiency and its command of all material aids to living, yet one has to ask one's self whether it is all really promotive of human happiness.

"People seem to be throwing themselves into work and pleasure with all that amazing vitality of theirs, really in order to escape something. I wonder what that something is. Whether it is just boredom, unhappiness or what."

Our critics seem to regard our habit of life as more in the nature of a quick-lunch rather than a leisurely well-ordered meal of which pleasurable association and exchange of thought and amenities is as much a part as the absorption of nourishment.

Perhaps in this land of urge and opportunity, there is less of establishment, of satisfied acceptance of the lot to which one has been born and of contented development of its cultural possibilities.

But one cannot get under the surface and bare the intimate life of a people in a few weeks' sojourn.

It is not surprising that a visitor should be impressed with the strenuous, informal and large-scale way in which things are done here, the satiety of the blasé pursuers of diversion instead of happiness.

But one to whom the doors and the hearts of the American people are opened will find abundant evidence that their "amazing vitality" and the means and leisure afforded by their working standards is not all devoted to dollar chasing and the seeking of unprofitable pleasure.

An increasing number of them are taking time to live.

EDITORIALS

Coal—Its Consumers Producers and Traducers

OF ALL the industries coal mining and marketing is probably the one that has had the hardest sledding for the longest time. It has been buffeted about from pillar to post, first for one cause and then another, until its economic senses seem to have become dulled and confused. The consequence has been a lack of cooperation and team work between coal producer and consumer through which both are suffering. The public utilities and large industrial power plants, which are among the biggest coal consumers, have taken care of themselves quite well by setting up their own standards for coal purchase and test, so the ragged front of the coal producers has been little handicap to them.

But there still remains a large proportion of the coal-purchasing public in the smaller industries and domestic consumers. These groups are more deeply interested in the coal problem than they themselves realize and perhaps more than the coal producer has realized. Tied closely into this background is also the smoke abatement, or, more broadly, the pure air problem.

More efficient operation of the railroads, public utilities and large industrial plants has been largely responsible for the decreased coal consumption even in the face of increased horsepower generated. But, paradoxical as it may seem, the coal companies must subscribe to and actively promote still further economies and betterment of coal-burning methods if they hope now to improve their business.

There is every reason to believe that a large number of the power-generating plants burning natural gas from long pipe lines will go back to coal when the gas companies find a sufficient and more lucrative sale for their surplus. So this is a market to be looked forward to.

Another large market for coal, at present but poorly developed, is in the smaller industrial plants. Many of these are in partial disrepute in their communities because of their tendency to make smoke. Despairing of being able to reestablish their popularity otherwise, some are considering a change of fuel. These facts lead to the thought that a campaign of education, teaching small power plant owners and operators to consider the dollars in the coal pile—backed up by a proper coal-vending service—will at once bring better operating efficiency and its corollaries, smokeless combustion and saving of money. From these advantages will come the return of interest in coal burning.

The domestic coal consumer needs treatment of another sort. Why not start a campaign for education in the rudiments of combustion and smokeless burning of coal in the home, by the public schools? The question of public health is so closely connected to pure air and city health boards are taking so much interest in the school children, it should not be difficult to enlist their aid.

Here are matters of interest to the power field, the smoke commissioners and vitally so to the coal producers. The Committee of Ten of the coal and heating industries has started off splendidly to do its job. Will others emulate their good example and get on the band wagon?

Test Corrections

TESTS were made on the early engines largely to determine their capacity. Later, increased fuel costs and competition between builders brought operating economy to the fore.

Early efficiency tests were crude as judged by present-day standards. The properties of steam were only roughly known and the measurements of quality were not always accurate. The need of data on steam properties, quality measurements and other test details started research and development, and these technical considerations are now fairly well known.

As more complete and more accurate tests were made, questions frequently arose on which the interested parties disagreed. Therefore to insure uniformity of test methods and to make tests of different units comparable, test codes were prepared. These have standardized test methods and have increased the accuracy of the results.

However, as it is seldom possible to secure on test the exact conditions under which guarantees have been made, it has been found necessary to correct the observed

results to the guaranteed conditions. For this purpose, test correction factors must be provided. These may cover such items as variations in pressure, quality, superheat, back pressure, speed, load, power factor, etc.

Unfortunately, no standard correction factors can be established for all classes of prime movers. These data can therefore come from two sources only. The various correction factors may be found by a series of tests where each factor is varied individually and its effect on the economy of the unit is determined. This involves a long, costly series of tests and is warranted only when a new type of unit is under development and the designers wish to determine its characteristics. The other source from which these data may be secured is from the computing engineers of the builders, who may be presumed to be able to predict the effect of changes in each factor involved.

Recent test codes call for agreement between the two parties to a test as to these test correction factors. Since it will apparently fall on the builder to provide these data, he should consider this as part of his contract and preferably make the test correction factors part of the original agreement, similar to the guarantees themselves. This is being done by many builders, but the practice should be extended.

At the same time it is incumbent on all engineers, whether designers or operators, who may be associated with tests, to familiarize themselves with the nature, character, and application of these test corrections so as to be able to judge intelligently whether the proposed corrections are rational and proper.

Uniform Valve Marking

POWER ENGINEERS everywhere will be interested to learn that the National Association of Purchasing Agents has established a committee to develop uniform markings for valves and fittings, and to promote their general adoption by manufacturers. The work is under the chairmanship of E. H. Weaver, district purchasing agent, Union Oil Company of California, Seattle.

Purchasing agents and others are greatly hampered in the identification of valves, and in the ordering of spare parts, by the lack of standard identification marks. Pressures, in particular, are a source of confusion. Some valves show the safe working pressures, others test pressures. Some manufacturers show figures for steam pressures, others for oil, water or gas. The numbers on some valves serve merely to identify the castings. Some give the date of manufacture. Serious inconvenience, and occasional accidents, have resulted from the misinterpretation of such markings.

The N.A.P.A. has invited the cooperation of the American Petroleum Institute, National Electric Light Association, American Standards Association, American Railway Association and other interested parties. The task may prove to be somewhat more difficult than would appear at first sight, but if some generally acceptable system of marking can be developed and "sold" to the manufacturers, it will be a worth-while contribution to the power field and to all others where valves and fittings are used.

Designers and Operators Should Cooperate More

TO GET the most out of a new plant it is important that the designing engineer acquaint the operating personnel with the purpose of all the equipment and how it is expected to function, individually and as a part of the whole. The operators, in turn, should inform the designers of all variations in performance or necessary departures in operating procedure from those contemplated.

That such cooperation does not always exist was well illustrated in one plant where the operator, when asked the purpose of certain equipment, replied that it was a gadget put in by the designer, but that it had never been used and he did not know what it was for.

Closer contact between designer and operator in the initial stages of the plant design makes for better operation, tends to prevent the installation of superfluous equipment, and enables the engineer to build better plants because of his more intimate knowledge of the operating problems.

* * *

THE employment section of the current *A.S.M.E. News* reflects the difficulty engineers now unemployed are having in finding new positions. In this issue but one position available is advertised, whereas sixty engineers are looking for employment. Analysis shows that designers and recent graduates are available in greater numbers than other classifications, there being nine of each. Seven executives and seven power plant engineers are looking for positions, but only five sales engineers. All are, of course, members of the American Society of Mechanical Engineers, with all the qualifications which that bespeaks.

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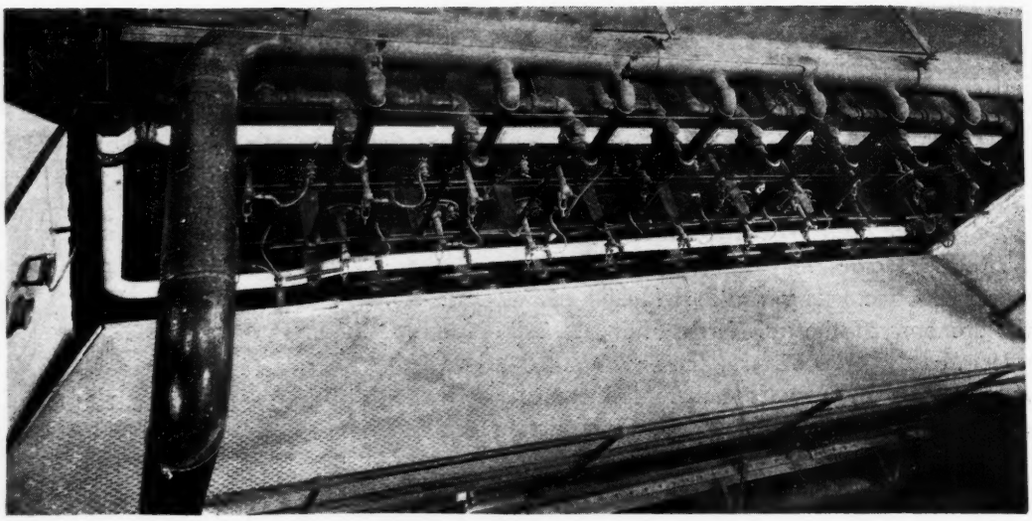
POWER Stands for . .

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**
8. **Prevention of Smoke, Within Reason**



Arrangement of gas and oil burners in front of new 1,400-lb. boiler at Deepwater, Texas

Natural Gas Burned Under New 1,400-Lb. Boilers at Deepwater, Texas

Steam at 800 deg. F. used in a thoroughfare reheater is feature of the extension at the Houston Light & Power Company

By J. B. NEALEY
American Gas Association

THE TENDENCY of public utilities supplying electrical power to substitute natural gas as fuel under the boilers for coal and oil is growing rapidly in certain localities as the savings in fuel costs, furnace maintenance and labor become better known. Already millions of cubic feet of natural gas are used daily for electrical generation, and the gain in 1929 over 1928 alone amounted to 50 per cent.

The trend is toward larger boilers with higher steam pressures and temperatures, and the use of economizers and air preheaters is also gaining rapidly. These improvements were incorporated in the design of the new extension to the Deepwater plant of the Houston Light & Power Company, Houston, Texas.

This company furnishes all of the electricity for the city of Houston and for more than 75 surrounding towns within a radius of 60 miles. It also furnishes some power to the street railway systems of Houston and Galveston, both local and suburban. Houston is supplied over several high-voltage lines, and the more distant parts of the territory over 66,000-volt loop lines.

Deepwater, originally built in 1924, contained four cross-drum boilers with air-cooled brick settings arranged to burn oil. These boilers had a maximum capacity of 160,000 lb. per hour each. On each of two subsequent extensions another boiler of the same physical size, but fitted with water walls, air heaters, induced-draft fans and combination oil and natural-gas burners and having a capacity of 325,000 lb. per hour, was installed. With the adoption of natural gas as a fuel it was also possible to add air preheaters and induced-draft fans to the four original boilers and to increase the output of each to 220,000 lb. per hour. This increase of 60,000 lb. per hour for each of the four boilers, or 240,000 lb. per hour total, saved the investment in another boiler. The furnace temperatures with gas are substantially lower than with oil, and this makes it possible to drive the boilers to higher ratings with gas than with oil without damage to the boiler brickwork from excessive temperatures.

The new boilers are of the single-pass, cross-drum type, equipped with water walls, superheaters, economizers and air heaters. Each is 44 tubes wide and 8 tubes high, the tubes being $3\frac{1}{4}$ in. in diameter. The designed working pressure is 1,450 lb. Total heating surface per boiler is 7,778 sq.ft. in addition to 13,820 sq.ft. in the economizer. The air heater, which is of the tubular type, has a heating surface of 31,154 sq.ft. The water walls, covered with cast-iron blocks, have an effective heating surface of 1,156 square feet.

The boiler drums are among the largest yet installed, weighing 118,500 lb. each. They are 43 ft. long and 5 ft. in diameter. To make them solid forgings were formed and then pierced and bored to an inside diameter of 52 in. and with a wall $4\frac{1}{4}$ in. thick.

The original boilers supply steam at 350 lb., 700 deg. F. to four turbines, two of 20,000-kw., one of 25,000-kw. and one of 35,000-kw. capacity. The turbines are direct connected to 12,000-volt, three-phase, 60-cycle generators, with extended shaft exciters.

The two new boilers supply steam at 1,300 lb., 820 deg. F., which passes through a thoroughfare steam reheater where it gives up some of its temperature and finally reaches the high-pressure turbine at 1,275 lb., 725 deg. F. Most of the high-pressure steam passing through the thoroughfare heater goes to the turbine, but a small

percentage is diverted to a dead-end reheater. Exhaust from the high-pressure turbine is at 360 lb. 460 deg. F. It passes through the dead-end reheater, where its temperature is raised to 560 deg. F. by the condensation of the high-pressure steam previously mentioned and thence through the thoroughfare reheater, where its temperature is raised to 710 deg. F. by the excess heat given up by the high-pressure steam on its way from the boiler to the high-pressure turbine. The exhaust steam, after having been reheated, passes to the 350 lb. mains, where it supplements the steam from the existing low-pressure boilers and is used in either the new 35,000-kw. machine, which is also being installed at this time, or in any of the four existing low-pressure turbines.

Gas is fired through twenty burners in each of the new boilers. The burners are set in the outer wall of the windbox and extend through the windbox to fire through ports in the furnace wall. Heated air for combustion is forced through the air heaters and ducts to the windbox by variable-speed, motor-driven, forced-draft fans. This air is supplied at pressures as high as 15 in. of water, and the gas pressures vary from 3 to 8 lb. Products of combustion are removed from the furnace by induced-draft fans, the flow being baffled so that the hot gas contacts the maximum heating surface and then passes through the economizer, the air heater, then the induced draft fans and out at the stack. At high ratings a suction of 15 to 16 in. of water may be required at the induced-draft fans.

The air heater consists of a sheet-metal box containing a bank of 2½-in. tubes, the hot products of combustion passing from the economizer into the box around the outside of the tubes. Air is forced through the tubes by the forced-draft fans and is delivered to the windbox at approximately 450 deg. F. The air heaters for the original boilers are of the plate type.

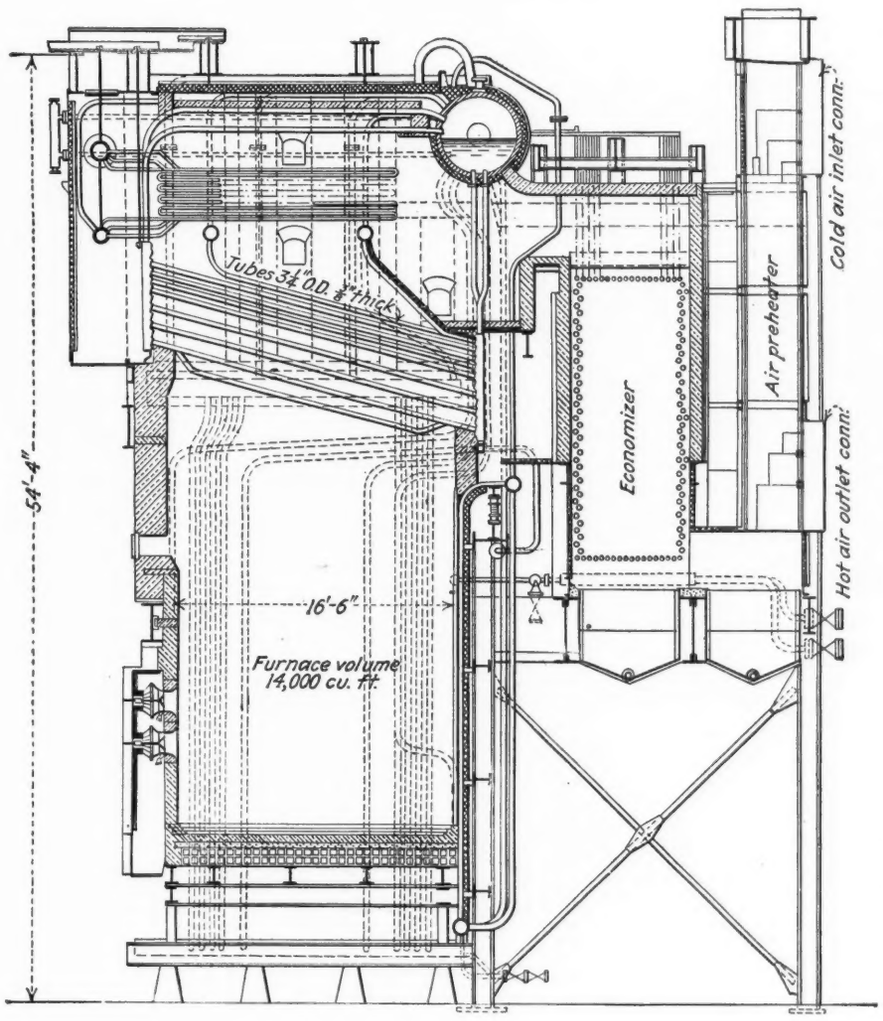
The burners consist mainly of the frame, air shutter and gas burner. There is also an oil burner attached for use when gas is not available. The frame consists of two cast-iron plates held together with bolts and pipe sleeves. The whole is inclosed with a series of sheet-steel segments, each segment mounted on a sleeve as a hinge, so that they can be opened or closed. The air for combustion is drawn through these doors, or vanes, from the windbox, its velocity and volume being controlled by increasing or reducing the amount of the damper opening and the pressure in the windbox. The outer plate of the frame is sealed into the outer wall of the windbox so that no cold air can leak into the furnace around the burner.

The gas burner proper is a hollow annual ring bolted to the inner plate of the frame, gas entering through one large inlet and issuing through numerous small ports in the inner periphery of the ring. The air entering through the shutter is given a whirling motion by the setting and shape of the vanes so that both air and gas are thoroughly mixed.

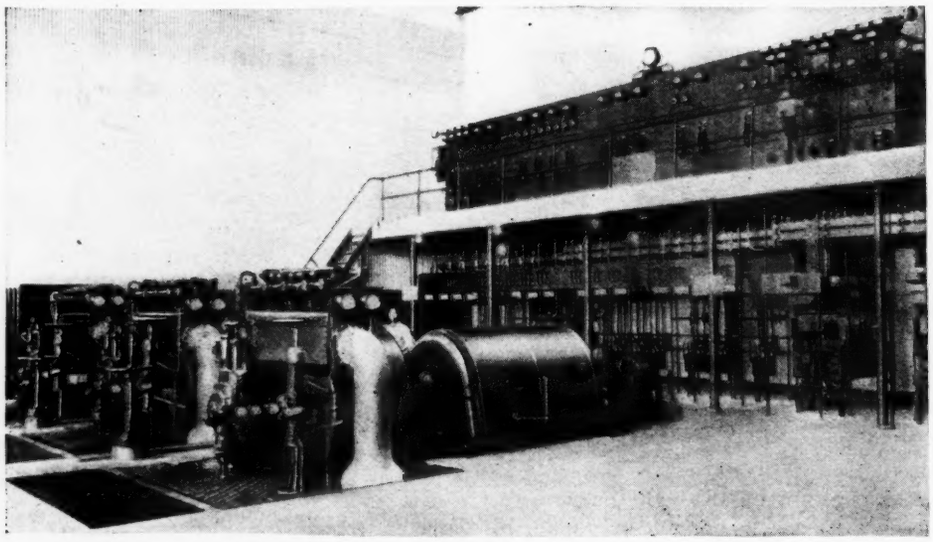
The new portion of the boiler plant is expected to operate at an annual efficiency of better than 80 per cent, using only 10 per cent excess air in burning the gas. The gas employed is of approximately 1,000 B.t.u. heat content with a specific gravity of about 0.57, based on air as unity. Each boiler requires approximately 490,000 cu.ft. of gas hourly when operated at maximum rating.

The use of gas at the plant has effected a saving of about 25 per cent in annual maintenance cost over the previous figures with oil firing. This is in spite of increased ratings on the boilers due to changes previously mentioned and to increased station loads.

Although a gain of a few per cent in boiler efficiency can be calculated for the use of oil instead of gas, actually—because of the steam required for soot blowing and for keeping the oil in the tanks heated and due to difficulties and expense of keeping the heating surfaces clean, maintenance, handling, and other factors—the use of gas has proved economical.



Cross-section of new gas-fired boiler at Deepwater, Texas, showing water-cooled superheater supports and economizer and preheater arrangement



Three 2,000-kw. 2,700- to 3,960-r.p.m. turbine generators for supplying constant and variable frequency (45 to 66 cycle) current to sugar-mill motors by varying the turbine speed

Motor Applications for Drives Requiring Speed Changes

By E. C. DIEFFENBACH
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Because of the nature of the work speed adjustments are essential in a multitude of motor drives, the ultimate object being to save power and to speed up production. Speed variations with motors may be obtained in many ways, fifteen methods being discussed here

ALL ELECTRIC MOTORS not of the constant-speed type may be classified as non-constant speed. These include the motor on a small machine-tool and the giant used to drive the rolls of a steel mill, and both direct- and alternating-current types.

In general, non-constant speed motors may be classified into four groups: Adjustable, adjustable-varying, varying, and multi-speed. These four classifications may be subdivided into motor types with explanations of how their speed characteristics are obtained.

Adjustable-speed motors are those which when once adjusted for a desired speed have practically constant speed with wide changes in load. Examples of these are the shunt, direct-current motor; the compound, direct-current motor with a small per cent of series ampere turns; the brush-shifting, commutator-type motor; the alternating-current motor operated on variable or multiple frequencies; and the direct-current motor under generator-voltage (Ward-Leonard) control. Alternating-current motors with Scherbius or Kraemer systems of control are other examples.

Adjustable-varying speed motors allow of speed adjustments, but have wide speed regulation under varying loads, the speed increasing with decrease in load. The wound-rotor induction motor operated with resistance in the rotor circuit comes under this classification. The speed, however, cannot exceed synchronism if the load is entirely removed.

Varying-speed motors have a wide speed variation inversely with the load. This is a desirable feature for some applications, as it tends to prevent overload, works rapidly on low loads and slowly on heavy loads, and causes two or more motors on the same load to divide the work correctly. In this class are the series-wound, direct-current motor, and certain types of brush-shifting, commutator-type alternating-current motors.

Multi-speed motors have two, three or four widely separated fixed speeds and may be operated at any one of them by a selective control; in some instances variations from the fixed speeds are provided for. The squirrel-cage, induction, two-, three- or four-speed motor; the synchronous motor with two speeds; the wound-rotor induction motor with two speeds, each adjustable-varying; and the induction two-frequency motors are designs to secure multiple speed.

When direct current is available, direct-current motors find ready application for adjustable-speed purposes, because of the fine speed adjustment that can be obtained

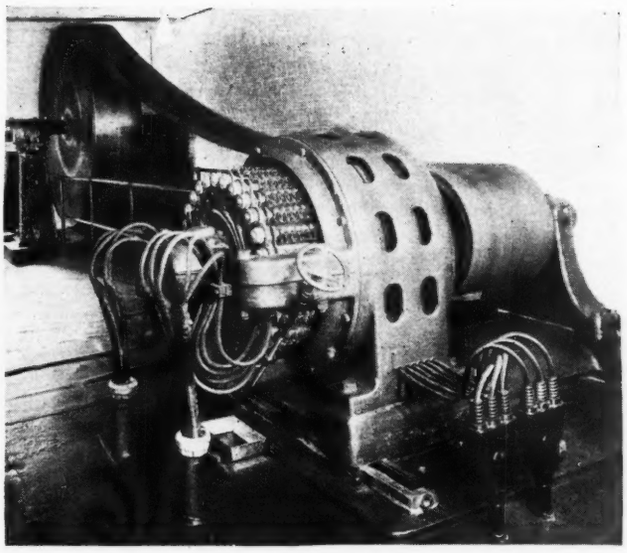

Fig. 1—A brush-shifting polyphase alternating-current 250-hp., 600-r.p.m. 4,400-volt motor driving a mine fan

in addition to wide speed ranges or reversal. Often direct current is used when an alternating-current supply is available, notwithstanding the added cost of conversion. The shunt motor has excellent speed regulation, and when adjusted for the desired speed the variation from this with load changes is small. Light compounding often assists in stabilizing and slowing the motor down on overload, or, in some cases, actually provides flat speed regulation where the motor would otherwise speed up on an overload.

Motor-field control is generally used for shunt motors. A combination of field and armature control may be used for very wide speed ranges. Standard starters are available which limit the initial current to 125 to 170 per cent of full-load value, giving a starting torque of 125 to 170 per cent of full-load running torque for shunt-wound and 130 to 195 per cent for compound-wound motors. The popularity of direct-current adjustable-speed drives is attested by the varied applications in many industries.

Where wide-range adjustable-speed, with or without reversals, and good speed regulation are required, generator voltage control, Fig. 2, offers a flexibility not excelled by any other type of drive. An alternating-current power supply can be readily adapted to it if direct current is not available. A direct-current generator driven by a squirrel-cage, a wound-rotor or a synchronous motor is the means of conversion. A generator is required for each motor or group of motors that operate as a fleet. Absence of sudden torque changes and shocks reduces mechanical wear and maintenance.

Control is secured by manipulating the relatively small generator-field circuits. The generator's voltage is varied from zero to maximum value with a corresponding change in the voltage to the driven motor. Motor reversing is accomplished by changing the polarity of the generator excitation. The motor must be separately excited. While this control provides an essentially constant-torque drive, constant horsepower can be approximated by modifications of the system. A combination of generator-voltage and motor-field control supplies constant torque at the low-speed range and constant horsepower at the higher speeds.

A car dumper uses generator-voltage controlled direct-current motors, Fig. 6. Other applications employing generator-voltage control are passenger and freight elevators, power shovels, mine hoists, materials-handling equipment, paper machines and many drives in the steel industry.

A commutator-type brush-shifting alternating-current motor is available that has a speed ratio of 3:1 and has shunt characteristics. On the commutator are two sets of brushes. Under normal operation the brushes are opposite each other, that is, on the same commutator bar, and the motor operates at synchronous speed with a small percentage of slip. If the brushes are shifted, the motor's speed goes above or below synchronism, depending on the setting. Control is comparatively simple and the motor may be started simply by connecting it to the line with the brushes in the slow-speed position. Current at start will be about 150 to 170 per cent, with starting torque approximately 200 per cent of full-load value.

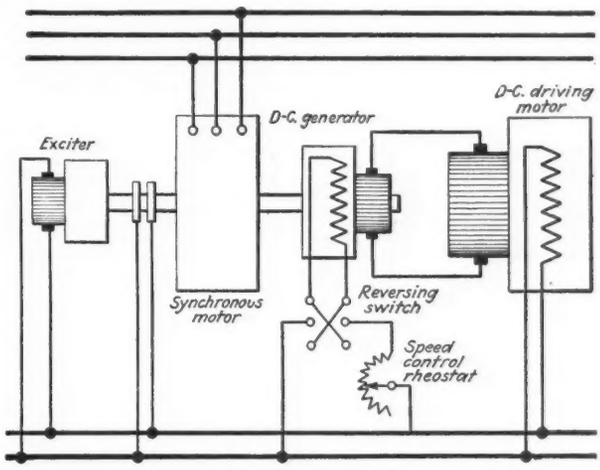

Fig. 2—Diagram of generator-voltage control for a direct-current motor

Examples for which brush-shifting alternating-current motors are suited are knitting machines, paper winders, printing presses, oil-refinery machinery, reciprocating pumps, stokers, bakery machinery and centrifugal compressors and pumps.

Adjustable speed by changing the frequency of the power supply, Fig. 5, can be applied to a group of wound-rotor motors whose relative speeds and loads do not vary too much. Usually the generator frequency is varied, the speeds of the motors varying as a fleet. Individual speeds can be reduced 10 per cent, relative to that of the fleet, by rheostatic control in the motor circuit.

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CLASSIFICATIONS OF NON-CONSTANT SPEED MOTOR DRIVES

1—Adjustable speed:
- (*a*) Shunt direct-current motors.
- (*b*) Compound direct-current motors.
- (*c*) Generator-voltage system (Ward Leonard).
- (*d*) Brush-shifting polyphase alternating-current motors with shunt characteristics.
- (*e*) Variable frequency.
- (*f*) Kraemer system.
- (*g*) Scherbius system.

2—Adjustable-varying speed:
- (*a*) Wound-rotor induction motors with resistance.

3—Varying speed:
- (*a*) Series direct-current motors.
- (*b*) Brush-shifting polyphase alternating-current motors with series characteristics.
- (*c*) Brush-shifting single-phase alternating-current motors.

4—Multi-speed:
- (*a*) Squirrel-cage 2-, 3-, and 4-speed motors.
- (*b*) Two-speed synchronous motors.
- (*c*) Two-speed wound-rotor motors with variation.
- (*d*) Two-frequency induction motors.

Rolling mills for crushing sugar cane are usually arranged in tandem with a motor for each roll with group speed control. The generating plant usually consists of three turbine-driven alternators, one for supplying adjustable frequency, one for constant frequency and one for other power supply (see photo on page 80). Control for each generator is centralized on one panel, and the load can be shifted from one to the other without closing down the mill. Another example of adjustable-speed by variable frequency is found in the run-out tables of a steel mill.

The Kraemer adjustable-speed control system, Fig. 3, operates from an alternating-current source of supply as a constant horsepower, or constant-torque drive, depending on the system installed. In the first case, the slip energy of the motor is converted to mechanical energy at the main drive shaft, and in the second case it is pumped back into the line as alternating current. The conversion of slip energy is made by a rotary converter and direct-current motor on the main drive shaft, or by a direct-current motor driving a generator which supplies direct-current into the line.

By manipulating the field of the direct-current motor on the main drive shaft or on the motor-generator, depending on the system, the counter-electromotive force acts through the rotary converter upon the main drive motor, and the speed is increased or decreased. Power-factor correction for the main motor can be secured by varying the field excitation of the rotary converter. Speed regulation with 60-cycle power supply is approximately 30 to 3 per cent below synchronism.

Three variations of the Scherbius adjustable-speed system, Fig. 4, are best described as constant-horsepower, constant-torque (from approximately 30 per cent synchronous speed regulation at 60 cycles) and constant-torque at approximately 25 per cent above and below synchronism. Each of the three systems consists, essentially, of a wound-rotor induction main driving motor and an auxiliary regulating machine.

With the constant-horsepower drive the main wound-rotor motor and regulating machine are mounted on the same shaft. The slip energy of the main wound-rotor motor is converted to torque by the regulating machine. With the constant-torque system the main wound-rotor motor and a motor-generator, consisting of a regulating machine and a squirrel-cage motor, are mounted as separate units. The slip energy of the main motor is supplied to the line by a squirrel-cage motor acting as a generator.

The equipment to obtain constant-torque adjustable speed with regulation above and below synchronism includes a main wound-rotor motor, an ohmic-drop exciter and a motor-generator consisting of a regulating machine and a squirrel-cage induction motor acting as a generator. The squirrel-cage motor supplies converted slip energy back to the power lines. By changing taps on the regulating machine's field-control transformer, the speed of the main motor is varied. With the double-range system speed can be varied from approximately 25 per cent below synchronism to 25 per cent above. The Scherbius adjustable-speed control system is well known to the steel industry.

The wound-rotor induction motor, when resistance is used in the secondary circuit, is termed an adjustable-varying-speed motor. Normally, at no load, the rotor runs at nearly synchronous speed. If a load is applied, the rotor slows down and the motor's operation becomes stable when torque and load balance. If a resistance is inserted in the rotor circuit, the rotor slows down still more; thus the speed can be adjusted but it varies with the load. For adjustable-varying-speed service, the stator control generally consists of a magnetic switch or oil

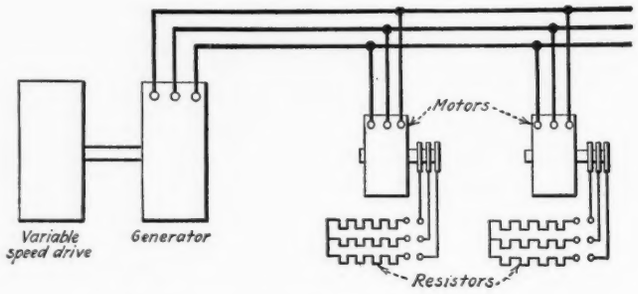

Fig. 5—Diagram of adjustable speed by variable-frequency system of control

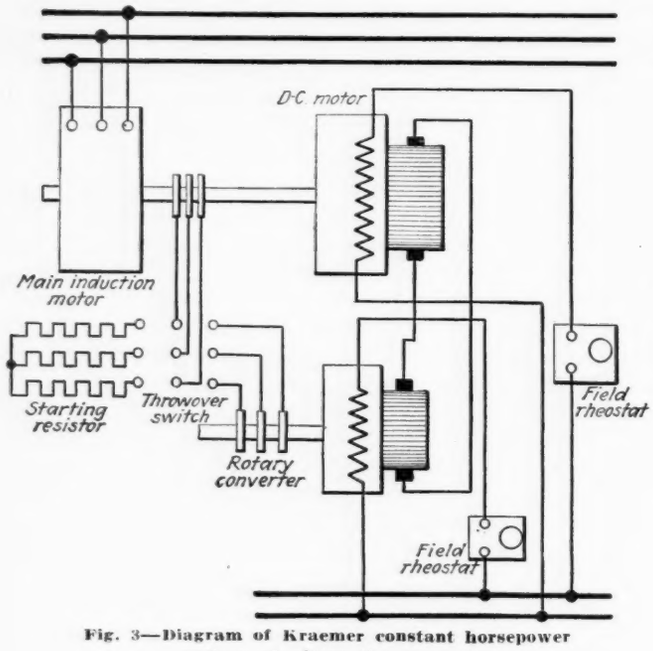

Fig. 3—Diagram of Kraemer constant horsepower system of alternating-current motor speed control

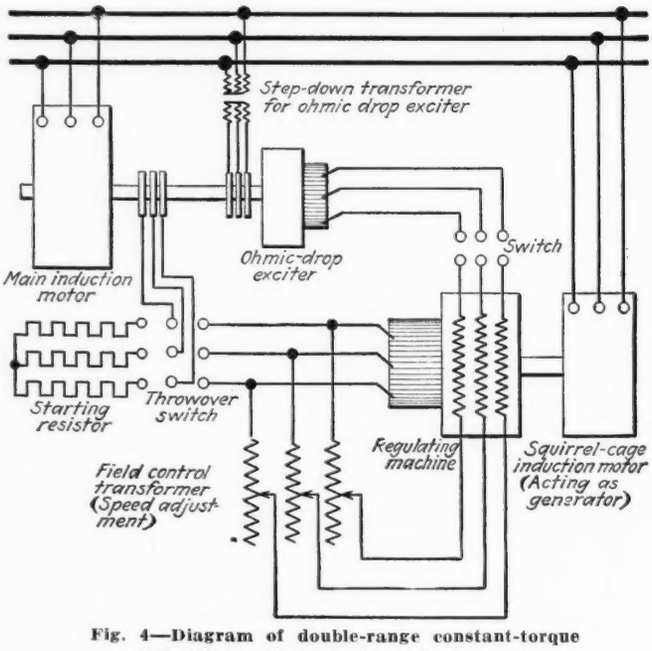

Fig. 4—Diagram of double-range constant-torque Scherbius system of alternating-current motor speed control

circuit breaker, and the rotor control is usually a speed-regulating rheostat or drum controller.

The varying-speed, series direct-current motor and the brush-shifting alternating-current single and polyphase motors with modified series characteristics are three popular drives where varying-speed characteristics are desired. The speed varies with the load and at no load attains an upper limit above synchronism with alternating-current motors. Modified series-motor designs permit of their use with belted connections. However, belted drives are not advisable for series direct-current motors, since the speed reaches excessive values at no load. The motor's inherent tendency to slow down on increase in load reduces the possibility of overload, especially at the higher speeds.

The speed of direct-current series motors is generally controlled by varying a series resistance, a decrease in

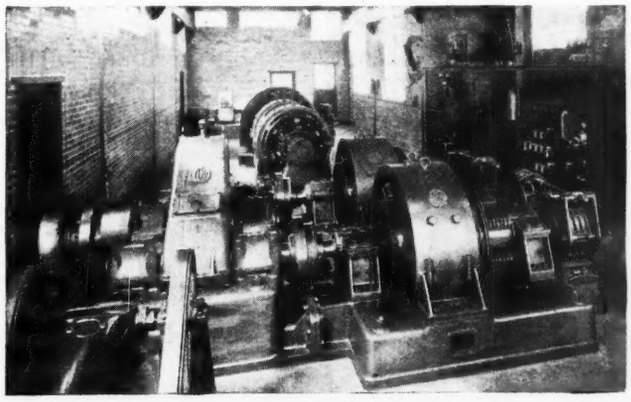

Fig. 6—Two 470-hp. direct-current motors with generator-voltage control on a car dumper

resistance increasing the speed. Numerous types of starting resistors, field resistors and drum switches, in various systems of manual, semi-automatic, automatic or remote control, are used for starting these motors.

Brush-shifting polyphase alternating-current motors are usually started by a switch or contactor through a suitable current-limiting relay and undervoltage protective device. Shifting the brushes adjusts the speed to the desired values. Control for the single-phase, brush-shifting motors ordinarily consists of magnetic starting switch, push-button station and brush-shifting mechanism. On account of the comparatively small ratings the motor may be thrown across the line.

A brush-shifting polyphase motor driving a mine fan, Fig. 1, is an example of a varying-speed drive from an alternating-current supply. The motor has series characteristics, and speed adjustment is secured by shifting the brushes manually. Speed changes are gradual from minimum to maximum and are accomplished without rheostatic losses, and the power factor can be kept at a relatively high value.

Alternating-current motors having several synchronous speeds at which they may be operated are usually termed multi-speed motors. Some of them have definite widely separated speeds only, while others may be varied somewhat from the synchronous speeds. The latter gives them a range of operation comparable with adjustable or adjustable-varying speed motors but lacking the smooth flow of power between transitions. Special windings are incorporated in multi-speed motors. Speed changes from the various base speeds (sometimes two, three, or four) are accomplished by changing the number of poles by a pole-changing switch (speed change by multi-frequency excepted). Examples of some of the more popular multi-speed motors are:

1. Two, three- and four-speed squirrel-cage motors
2. Two-speed synchronous motors.
3. Wound-rotor two-speed induction motors with considerable variation from the synchronous speeds.
4. Wound-rotor two-frequency motors with some speed variation from the synchronous speeds.

For some applications multi-speed motors will fulfill all the requirements just as well as adjustable-speed drives and with the added attraction of somewhat lower cost and greater simplicity. Such applications are found where there exist distinct duty cycles, such as low speeds for oil-well pumping and high speeds for pulling the pumps, bailing, pulling and setting the casing pipe; low speed for the first pass in a steel-rolling mill and two or more higher speeds for the finishing passes. Seasonal demands or varying outputs during different times of the day are other illustrations. Blowers, pumps and feeders fall into this classification. Gradual starting or stopping of heavy loads, such as elevators or car dumpers, where their inertia would introduce severe shocks, forms another class of service.

The squirrel-cage motor is one of the most popular multi-speed motors in industry; various base speeds are secured by regrouping poles in some manner as previ-

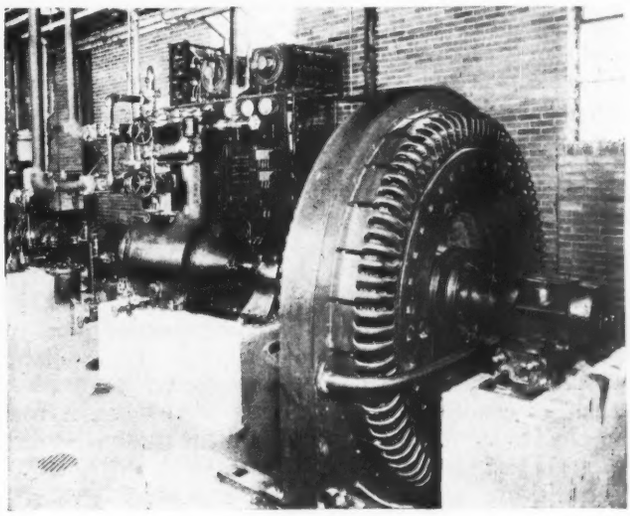

Fig. 7—One of two 2-speed 25- and 50-hp. synchronous motors driving reciprocating compressors in a refrigerating plant

ously mentioned. Multi-speed motors are arranged as standard for four constant synchronous speeds, 1,800, 1,200, 900, and 600 r.p.m., the full-load speed being approximately 4 per cent lower. Two-speed motors are available for constant-speed, constant-horsepower operation at 1,800 and 900, 1,200 and 600, and 900 and 450 revolutions per minute.

The airplane carriers Lexington and Saratoga of the United States Navy are equipped with two-speed 22,500-hp. modified squirrel-cage motors. These motors operate at variable frequency and are of 22- and 44-pole design, speed change being accomplished by changing poles and varying the turbine speeds. At low speeds not all of the turbines are required.

The list of multi-speed applications is long, but the following are a few examples of applications requiring a number of speeds: certain kinds of pumps, fan blowers, centrifugal machines elevators, mangles in laundries, and dough mixers in bakeries.

Practical Record of 400-Lb. Operation in an Industrial Plant

Every pioneer can figure on a certain amount of trouble. Here is an interesting practical record of experiences with a 400-lb. industrial plant about three years ago when this pressure was still relatively rare in the industrial field

By G. R. HOFMANN

THE PLANT under consideration employed more than 1,000 men. It used large quantities of process steam at 40 lb. pressure, some in jacketed tanks and some introduced directly into the liquid being heated. The steam requirements ranged from approximately 30,000 lb. per hour in summer, for process, air compressors and auxiliaries, to 56,000 lb. per hour in winter, for the foregoing, plus heating. The old boiler plant consisted of four 3,500-sq.ft. vertical water-tube boilers operating at 125 lb. pressure.

Original Plant Operated At 125 Lb.

Steam from the old boilers was used for one 400-kw. geared, condensing, bleeder turbine-generator unit, two 500-cu.ft. steam-driven air compressors, auxiliaries, process and heating. The turbine was served by a low-level jet condenser, and was run only when it could be bled to the factory heating system. All power not so generated was purchased.

In the operation of the old plant the 40-lb. steam for jacketed tanks was supplied from the high-pressure mains through reducing valves. A few tanks built for 125-lb.

> **"The compound prevented scale, but laid down a slimy deposit which was apparently an excellent heat insulator, and which caused tubes to burn out in 125-lb. boilers as well as 425."**

pressure, and operated directly off the high-pressure steam line, had a small aggregate demand.

It was thought that by generating steam at high pressure, and using a turbine as a reducing valve, considerable power could be generated. It was also thought advisable to run the 125-lb. turbine throughout the year, since this unit could compete with purchased power if furnished with steam from an efficient boiler unit.

A 750-kw., 80 per cent power factor turbine was purchased, designed for throttle conditions of 400 lb. and 100 deg. superheat. The turbine was to exhaust at 55 lb. gage and 15 deg. superheat. It was a three-stage unit, consisting of one impulse following two reaction stages. Steam was bled at 125 lb. after the first stage.

The boiler purchased was a cross-drum, continuous header, horizontal boiler, 21 sections wide, 13 tubes high, tube length 22 ft., fired under high end. The tubes were good for 475 lb., and the cost of strengthening the drum

> **"A small pump was built and connected to valve gear of feed pump to inject a small dose of phosphate with each stroke, exactly proportioning the phosphate feed to the boiler feed. This method proved entirely satisfactory."**

to bring its allowable pressure into line with that of the tubes was only nominal, so a boiler good for the higher pressure was purchased. Guaranteed efficiency ranged from 78.7 per cent at 100 per cent of rating to 74.1 per cent at 300.

A superheater of the bare-steel-tube type was located between the first and second passes.

An engine-driven underfeed stoker, seven retorts wide and 29 tuyères deep, having single steam-operated dump plates, was purchased to fire the boiler.

A steam-driven, outside packed, duplex plunger pump was provided for boiler feed. The steam end was for 125-lb. operation, but was of such size that the pump would feed the boiler when steam fell as low as 90 lb. A plunger pump was given the preference over a centrifugal, for two reasons: (*a*) greater reliability; (*b*) passages in a centrifugal pump of the required capacity would be very small, so that any sludge or scale deposited would quickly reduce the pump capacity. For emergency service two double-tube injectors were provided.

Feed-water control was by means of an expansion tube type of thermostat, having the tube in tension. Damper stoker and forced-draft-fan speed controls were by a well-known make of master regulator, in which the steam

pressure acted on a diaphragm, and was balanced by weight on a level carried on knife edges.

Steam was purified before leaving the drum by dry pipes and a centrifugal type of steam purifier, drained externally to its trap.

Boiler Compound Not Satisfactory

Many troubles were encountered in getting this plant into operation. The first was boiler scale. A boiler compound was being tried at that time which a neighboring plant claimed gave them excellent results and

> "The only drawback of the phosphate water conditioning was that no turbining was needed and so the tubes fouled at points which soot blowers did not reach effectively. Turbining vibrates the tubes and causes this external fouling to fall free."

freed them of the necessity of turbining tubes. This compound was claimed by its manufacturers to be a vegetable colloid. Actually, it was extremely caustic, and proved on analysis to be chiefly water and caustic soda, with some tannic acid and trisodium phosphate. The compound prevented scale, but laid down a slimy deposit which was apparently an excellent heat insulator, and which caused tubes to burn out in 125-lb. boilers as well as 425.

This compound was then discarded, and the lime-soda process was followed by an application of trisodium phosphate. This did not prove satisfactory, due to poor control. Samples of boiler water were drawn every morning and sent to plant laboratories for analysis. Six to eight hours would elapse from the drawing of the sample to the receiving of analysis report in the boiler house. If, during this period, the treatment was off, scale was deposited. Upon bringing up the treatment, scale which had formed cracked off the tubes. This would collect at one point in the tube and block circulation, causing tubes to burn and blister. One burst blister, at this pressure, was usually enough to cause a shutdown.

> "The steam lines were originally put up with wire-inserted asbestos gaskets. These soon gave trouble and were replaced with ordinary asbestos-and-rubber composition gaskets, after which there was no further trouble."

A firm of water-conditioning specialists was then called in, and its test cabinet was installed in the power house. This reduced a test to a matter of minutes, and tests were now readily made by the engineer. Every six hours determinations were made of total and hydroxide alkalinity of the feed water, and total alkalinity, phosphate concentration and sulphate concentration of the boiler water. From the sulphate concentration blowdown was controlled, and, by means of a chart, the phosphate concentration, so as to prevent formation of scale.

It was found that the treated water from the purifiers was murky. Upon testing each purifier separately, it was found that the water from one was overtreated, while that from the other was undertreated. Further investigation revealed the fact that one of the orifices in the water dividing box had become enlarged in some manner. Other difficulties were found, but the troubles were corrected.

At first, phosphate was fed into the suction line of the boiler feed pump in batches. This was soon found to produce rough boiling immediately after phosphate had been fed. Therefore, a small pump was built and connected to valve gear of the feed pump to inject a small dose of phosphate with each stroke, exactly proportioning the phosphate feed to the boiler feed. This method proved entirely satisfactory.

It was found that boiler alkalinity ran very high even when using di-sodium phosphate. Later a small amount of 50 per cent phosphoric acid added to the phosphate solution kept down the boiler alkalinity.

Phosphate treatment entirely eliminated tube renewals in this plant. The 125-lb. boilers were free of tube scale, except those tubes which received the feed water. The 425-lb. boiler accumulated a paper-thin scale which immediately flaked off and was swept out of tubes by the circulation. The action of the phosphate treatment is selective in that the hotter the tube the less the scale that forms.

The only drawback of the phosphate water conditioning was that no turbining was needed and so the tubes fouled at points which soot blowers did not reach effec-

> "The boiler feed pump was furnished with bronze water valves, and seats. These cut out after about five months' service. They were replaced in nickel alloy and gave no further trouble."

tively. Turbining vibrates the tubes and causes this external fouling to fall free.

Considerable trouble was experienced, for the first six months, with leaks in the boiler drum. These occurred mostly at feed and water column nozzles, and many rivets had to be replaced. Some of these were found loose in holes. Leaks occurred also along the butt strap, along the reinforcing plate where horizontal circulating tubes entered the drum, and around two vertical circulating tubes. No further trouble was experienced after the seams were calked and tubes re-rolled.

The most troublesome leaks were in threaded joints, where screwed flanges were used.

The steam lines were originally put up with wire-inserted asbestos gaskets. These soon gave trouble and were replaced with ordinary asbestos-and-rubber composition gaskets, after which there was no further trouble.

Boiler handhole plate gaskets gave no trouble when properly attended to. If handhole plates were tight on hydrostatic test they remained so in operation. Also, plates leaking under hydrostatic test continued to leak when steaming.

The trap draining the steam purifier caused considerable trouble, which may be classified under three heads: (*a*) binding of pilot trap linkage by sediment, making trap inoperative, remedied by installing smaller pilot seat; (*b*) warpage of body casting, binding main valve oper-

ating piston; (*c*) wear of pilot linkage, making pilot inoperative.

Due to the first cause and to the fireman's running up the water level too high (by means of hand valve on emergency feed line), prior to blowing down the boiler, a slug of water entered the turbine, stripping some blading out. Due to the last two causes, it was necessary to replace a complete set of superheater elements in about a year's time. Also, the dry powder carried over by steam ground out carbon packing rings in the turbine and caused excessive gland leakage. All these

"The tubular gage glass was very troublesome. The maximum life ever obtained from any make of glass was 27 days."

troubles vanished when the trap was replaced by one of another make.

Considerable annoyance was caused by injectors. These were very sensitive to water pressure on the inlet side. Also, for operation at 425 lb. pressure, the handles were too short to get smooth action. The side rods buckled under the strain of operation. One check valve and seat unscrewed, while another came apart. One of the nozzles had a piece burst out of side. The injectors were returned to manufacturer and rebuilt with different sized nozzles, longer handles and stronger parts, and thereafter were satisfactory.

Chrome-steel-trimmed valves were installed on steam and water lines. These were deemed superior due to the close agreement of the coefficients of expansion of steel of body and trimming, but proved disappointing, many of the valves not closing tight.

Another source of trouble was the bypass on large valves. This was made up of valve, two elbows and two flanged unions, all screwed. The bypass pipe was not arranged as an expansion bend, and as a result thread leaks were caused. After trouble with various types of globe valves nickel-alloy-trimmed, forged-steel globe valves having the disk made as a long cone were tried. These eliminated all trouble except a slight grinding every few months. The boiler blowdown valves were furnished bronze-trimmed. The bronze parts cut out and were replaced with nickel-alloy parts, which gave satisfaction.

The boiler feed pump was furnished with bronze water valves and seats. These cut out after about five months'

"The boiling was so smooth that a stranger would believe that water column was shut off. The water never lifted in the drum, except when main relief valves blew."

service. They were replaced in nickel alloy and gave no further trouble.

The tubular gage glass was very troublesome. The maximum life ever obtained from any make of glass was 27 days. The glass finally adopted showed the best life of any, but was etched out at top by condensate until the end became thin and packing could not be held. This make of glass rarely burst. Other makes burst frequently, as many as eight having been used in twelve hours.

Gage-glass packing washers were also quite a problem for a while. After many experiments a combination packing consisting of two end rings of very hard canvas-and-rubber combination and a middle ring of braided asbestos and rubber rod packing was tried. This proved very satisfactory, and was found to outlast the glasses.

In addition to stripped turbine blading and worn carbon packing rings, as already mentioned, the turbine had two new bleeder diaphragms and many gages on oil lines. The semi-steel diaphragms sprung enough under the difference of pressure acting on them to rub a wheel. Semi-steel particles tore off and welded to a wheel until enough had built up to break the diaphragm. After two diaphragms had failed the turbine builder furnished a heavily ribbed steel diaphragm, and no more trouble was experienced.

The oil gages gave much trouble. Gears and linkages wore out and tubes ruptured. The turbine builder furnished new gages and two special oil relief valves, so built that they did not open or close suddenly. These did away with pulsations and remedied the gage trouble.

Outside of the generation of byproduct power the chief advantages of high-pressure steam are smooth boiling and small steam lines.

The boiling was so smooth that a stranger would believe that the water column was shut off. The water never lifted in the drum, except when the main relief valves blew. There were times when the sulphate concentration reached 12,000 p.p.m., which corresponds to a

"The only troubles encountered that would seem to belong inherently to a high-pressure installation were the rapid deposition of scale with ordinary water-conditioning methods, and tubular gage glass trouble."

total solids concentration of 40,000 p.p.m. Even under these conditions boiling was smooth and no appreciable difference was noted in the amount of discharge from the steam purifier trap. This condition was, of course, due to the low volume occupied by a given weight of steam at this pressure.

Because of the small volume of a pound of steam at 425 lb., the steam lines can be greatly reduced in size without producing a high friction loss. For instance, to handle 56,000 lb. of steam per hour the turbine was provided with only a 5-in. governor valve.

The only troubles encountered that would seem to belong inherently to a high-pressure installation were the rapid deposition of scale with ordinary water-conditioning methods, and tubular gage glass trouble. The scale was eliminated. The gage-glass trouble was minimized and could have been eliminated by installing a flat gage.

The valve and threaded-joint leaks were due to the high total temperature, and would undoubtedly occur on a moderate-pressure, high-superheat installation having the same total temperature. The thread leaks could be eliminated with comparatively little additional expense by using van stone joints.

There would not seem to be any good reason why high pressure should not be used in industrial plants on all future installations, the additional cost being but little greater than for a moderate-pressure installation, and the advantages are considerable, particularly if power is to be generated.

CORROSION: WHAT IT IS

It has been conservatively estimated that loss through corrosion of iron and steel annually requires the replacement of about two per cent of the entire tonnage of these two metals in service. As such it represents a drain upon our natural resources of iron ore. While corrosion has been considered a simple chemical reaction, unfortunately all of the factors involved in the process are not understood very well. This is the first of a series of three articles, the second and third of which will discuss the use of alloy metals and the application of protective coatings.

By W. S. JOHNSTON
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CORROSION is a natural phenomenon of disintegration occasioned by one substance reacting chemically upon another for which it, or one of its components, has an affinity. In this and subsequent articles only corrosion between iron and steel and water, neutral or acidulated, will be discussed. It is the form of corrosion most generally found in power-plant equipment, and obtains in some degree whenever iron and water are in contact, unless the surfaces of the former are shielded by a protective coating.

Every facility is at hand that permits corrosion to take place, working quietly and unobtrusively, yet breaking down the structure, a particle at a time. It occurs day and night without cessation, not alone in equipment that is in active service, but often to a greater degree in idle equipment.

The corrosion of the surfaces of iron and steel subject to contact with water is well known. The visual effect is referred to as rust. Upon close inspection of a recently rusted surface there is found a series of excrescences, each more or less individual and isolated, though some may overlap. Each excrescence, however small, is a particular point of attack, a vulnerable spot in the structure especially susceptible because of its nature and location.

The attacking force is carried in the water. Let it be assumed for the moment that the water is such as is ordinarily considered drinkable and palatable. It is a simple chemical composition of hydrogen and oxygen, the latter capable of causing corrosion by itself under certain conditions, but chemically inert in combination with hydrogen. Under all ordinary circumstances water may be considered as a stable union of hydrogen and oxygen, though dissociation may occur at elevated temperatures, but of this phase more will be said later. Hence, water as such is not particularly harmful to iron and steel, but it has a property that is deleterious. It can acquire an excess of oxygen from the air and carry it in solution. It may carry small entrained bubbles of air not ordinarily visible. Each bubble of air contains 21 per cent of oxygen by volume. It is the oxygen carried in either manner that attacks the iron and steel in the presence of water and causes corrosion. It is capable of corrosive action without the presence of an acid.

Pitting Found Beneath Rust

If the excrescences are closely examined it will be found that they are successively layers of rust. Carefully removing the rust down to the basic metal reveals a small indentation in the structure, a pit caused by corrosion. Upon the initiation of rusting only the outer surface is corroded but, as the water seeps below the first layer of rust, the oxygen it carries has an opportunity to make contact with another heretofore untouched surface of the metal, which it promptly proceeds to corrode. Thus, through repeated attacks on a vulnerable point, the metal is eaten away and a pit is made. The pit may be large or small, but it is there just the same and constitutes a weakness in the structure.

What is commonly spoken of as rust has a distinctive reddish color, though it may appear to be of a brown cast. The substance of rust is the result of a union of oxygen and iron in their elemental states represented by the chemical symbol Fe_2O_3. It is known as ferric rust. Below the reddish rust and next to the uncorroded metal is a film of black ferrous rust, Fe_3O_4. In corrosion under water this latter form may account for one-third of the corrosion products, while in the air its amount is small. As all oxidation is a form of combustion, it may be considered that the iron has been burned in the presence of oxygen with the liberation of heat, though the process has been so slow that no appreciable amount of heat is apparent at any one time.

In the foregoing there has been considered the case where water is the vehicle, or catalyst, and the included oxygen the agent directly responsible for corrosion. On the other hand, oxygen alone or available in combination

as in dry air cannot produce a corrosive effect on either iron or steel without the presence of water.

Carbonic acid is present in the air everywhere but, if dry, will not attack iron or steel. In solution with water it is the agent which determines corrosion in the atmosphere. It is present in ordinary water having been absorbed from decomposed vegetation in the ground during the run-off after rain or from the atmosphere. It may be picked up also if the water flows over areas having mineral deposits of carbonates. It may be unavoidably added in the treatment of boiler feed water. In the latter two cases heating the water breaks up the carbonates liberating carbon dioxide which immediately goes into solution in the water as carbonic acid. The union of carbonic acid with iron and steel produces a corrosive effect evidenced by a white precipitate of carbonate of iron, $Fe(HCO_3)_2$.

Effect of Sulphurous Acid

Another similar case is that of sulphurous acid resulting from a combination of sulphur dioxide and water. The former is an extremely active corrosive agent due to the presence of the latter, especially if the iron or steel surface is covered with a moisture absorbing substance, such as soot on the outside of economizer tubes.

Ammonia may be formed from the nitrogen of the air during the process of corrosion, but probably due to its inactivity is not a factor in corrosive action. Chlorides frequently are a contributing corrosive factor, the acid being liberated by decomposition of the chloride salts in the water upon heating. The same is true in the case of water carrying sulphides in solution.

The types of corrosion mentioned so far can occur at all temperatures above the freezing point of water and are independent of the usual pressures obtaining. However, as the temperature increases, the opportunities for corrosion multiply as the water will liberate any air that is entrained and any oxygen that is in solution. Further heating also breaks down salts carried in solution releasing the acid radical to combine with water and thus establish a weak acid.

The recent use of high steam temperatures has developed another phase of the corrosion of iron and steel. Recent tests at 1,000 deg. F. show that the steam as water vapor dissociates to some extent into hydrogen and oxygen, the latter combining with iron to form the black oxide of iron, Fe_3O_4. While the amount of such dissociation is believed small, yet it is a factor that must be considered as the use of high steam temperatures increases above the prevailing maximum of 800 deg. F.

A technical summary may be made of the foregoing elementary presentation of the causes of corrosion. From the standpoint of the theory of solutions all reactions which take place in the presence of water are attended with certain readjustments of the electrical states of the reacting ions. The electrochemical theory of corrosion proceeds upon the fact that, before iron and steel can oxidize in the wet way, they must pass first into solution as a ferrous ion. In the ordinaary cases of corrosion in water part of the hydrogen of the water, is displaced and liberated as such to form a gaseous film on the surface of the iron. The latter goes into solution as a metallic hydroxide up to a certain maximum concentration in pure water without the aid of oxygen or other reacting substances. This theory is now generally accepted as the one best expounding the known facts of corrosive action.

Broadly speaking, corrosion according to this theory is a reaction between metal and water forming the hydroxide of the metal with the liberation of hydrogen, in which the following factors are pertinent:

The tendency possessed by each metal to dissolve in water is known as its solution pressure and is measured by the potential of the metal when in a solution of one of its salts. The solution pressure of iron is about midway of the scale of the known metals, potassium having the maximum and platinum the minimum pressure.

Water breaks up into hydrogen and hydroxyl ions, the greater the concentration of the former the more rapidly the metal dissolves. Mention has already been made of the increased corrosive effect of water carrying acid gases in solution, such as carbon and sulphur dioxides.

The hydroxides of metals are factors in corrosion only when they are in solution with the water, but most of them are not water soluble and hence have little direct bearing on corrosion. Their indirect influence is to hold moisture and oxygen in contact with the metal as they are likely to form a spongy mass on the surface of the corroding parts.

The liberated hydrogen, however, acts as an inhibitive to corrosion by forming a gaseous film on the metal. It may prevent or retard further action. However, the continuation of hydrogen film is prevented in a measure by the fact that hydrogen and oxygen unite to form water when in contact with an iron surface, though the union takes place slowly. Hence, the oxygen dissolved in the water removes the protecting film of hydrogen gas and corrosion proceeds, as the greater the oxygen solution pressure the more readily water is formed. The hydrogen bubbles may escape also as a gas.

The solution of iron in water and the consequent deposition of hydrogen is accompanied by a flow of electrical energy, the formation of the gaseous film being referred to as polarization and its prevention by oxygen as depolarization. The inherent electromotive force causing a metal to dissolve is relatively small and the currents flowing minute in the cases of iron and steel. This action must not be mistaken for electrolytic corrosion.

Depolarization Removes Protecting Film

Corrosion of iron can be considered as taking place in two steps. The first is that in which a small amount of the metal is dissolved and forms a coating which retains further solution of the iron. If the reaction were to stop at this point the extent of the corrosion would not be serious. However, because of the depolarizing effect of the oxygen present, the protecting film of hydrogen is removed. The second step is the solution of more metal which is immediately thrown down as rust. Oxygen is very soluble in water at normal temperatures, and is absorbed readily when it is used up as in the process of corrosion. The rate of corrosion is directly proportional to the amount of oxygen dissolved in the water.

In passing it is desirable to identify electrolytic corrosion. It is the result of metal breakdown by stray electric currents frequently traversing pipe lines, which cause damage by making deep pits where the current leaves the line. Galvanic action is another form of corrosion which takes place when two metals, one electronegative to the other, are in contact with each other in the presence of moisture.

The majority of the cases of corrosion can be divided into two classes. The first is that of the metal being exposed to the action of moisture and oxygen, the latter

predominating as in the case of the atmosphere. The second is that where the metal is submerged and water predominates, the oxygen being limited to that dissolved in the water entering the system.

While both cases obtain for power-plant equipment, the second presents the greater concern as it progresses unseen and its magnitude is generally unknown. The important factors in this case are not only the amount of oxygen available, but particularly the condition of the surface. In the instance of steel this is the character and amount of mill scale which remains on the finished surface.

Removal of Mill Scale Reduces Pitting

Pitting is generally much deeper near mill scale where it is thick and adheres firmly, probably due to the electro-negative character of the scale with respect to the iron. Removal of mill scale greatly reduces the tendency to pit if the metal is fairly homogeneous and free from strains. Surface finish is a greater controlling factor in corrosion than is the composition of the metal of which the equipment is constructed.

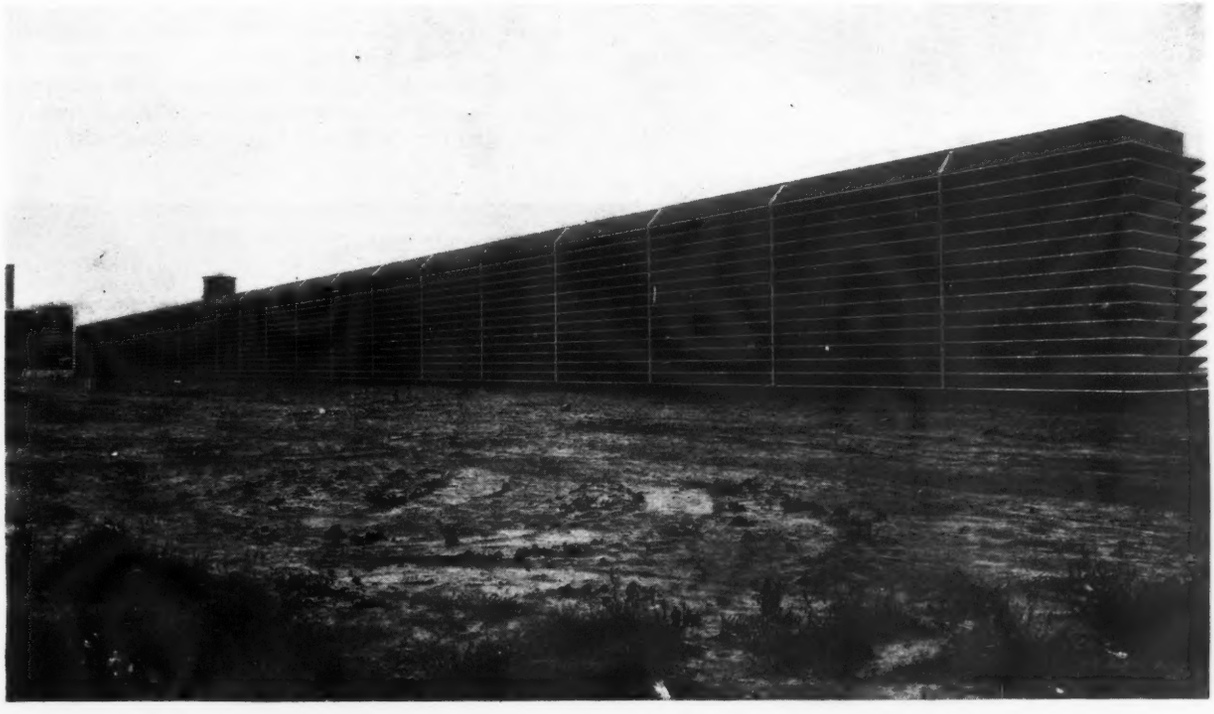
Corrosion is influenced, too, by overstressing the metal, as in the steel plates of pressure vessels, especially steam boilers. The explanation commonly accepted is that the overstressed metal is electro-positive to the unstrained metal and the current finds a path of lesser resistance through the electro-positive metal. Hence, the latter corrodes faster. Corrosion cracking, on the other hand, often occurs without externally applied stress. It is the result of combined internal initial stress in the metal and surface corrosion.

Cavitation is also a factor in corrosion. It occurs in improperly designed pump impellers, water turbine runners and ship propellers where voids are formed as the water leaves the surfaces. It is thought that under these conditions nascent oxygen is released and corrodes the damp surface of the metal.

Corrosive actions of the nature discussed in this article may occur in every power plant. They attack the structure of the piping with its valves and fittings, steam boilers, furnace water walls, superheaters, economizers, condensers, coolers, evaporators, deaërators, heaters, water storage tanks, pumps and all other equipment handling and containing water, as such, and steam, either saturated or superheated, if the temperature of the latter is sufficiently high. No part of the equipment is free from possible attack unless preventive means are used.

▼ ▼ ▼

LARGEST ATMOSPHERIC TOWER



The Texas Utilities Company has installed at its new plant near Lubback, Texas, an atmospheric-type cooling tower said to be the largest in this country and probably in the world. It is 706 ft. long and has a capacity of 32,500 g.p.m. The present installation is one of two units that will serve an ultimate plant capacity of 50,000 kva. Only 10,000 kva. is now in operation. The tower, designed and erected by the Schubert-Christy Corporation of Affton, Mo., was constructed of nearly one million board feet of select cypress. It cools the water to within 3 deg. of the wet blub temperature and the makeup amounts to less than one per cent. Since being placed in service it has been required to withstand a wind of over 60 miles per hour, extreme temperature changes, and keep out the beating sands that prevail on the high plains of Texas.

Welded Equipment for the Power Plant

By GEORGE G. LANDIS
Chief Engineer The Lincoln Electric Company

Fig. 1—A unit for burning pulverized coal. Air box of bolted construction

Fig. 2—Unit of Fig. 1 redesigned for welded construction

POWER engineers and power equipment manufacturers are realizing the great variety of advantages made possible in manufacture from all types of metal designs by the substitution of arc-welded steel construction for traditional and often reactionary methods. Not a small factor behind this progressive attitude has been the development of reliable and dependable methods of fusion fabrication with the electric arc.

The advantages of speed, economy and simplicity of design have long been recognized. Research and experiment have enabled welding technicians to advance processes which result in welds of extreme density. Welds of toughness, ductility and tensile strength as great or greater than mild rolled steel are now possible with the use of special fillers, fluxes and electrodes.

In the power field, as in many others, arc welding and arc-welded equipment can effect great economies. Cast iron and riveted steel are being supplanted by this more modern process of fabrication in the manufacture of furnaces, boilers, pulverizers, burners, economizers, blowers and condensers. Welding is used not only for the installation of pipe, pipe fittings and other equipment, but also to reduce the time and cost of maintenance.

The pulverizer shown in Fig. 4 has a capacity of 15,000

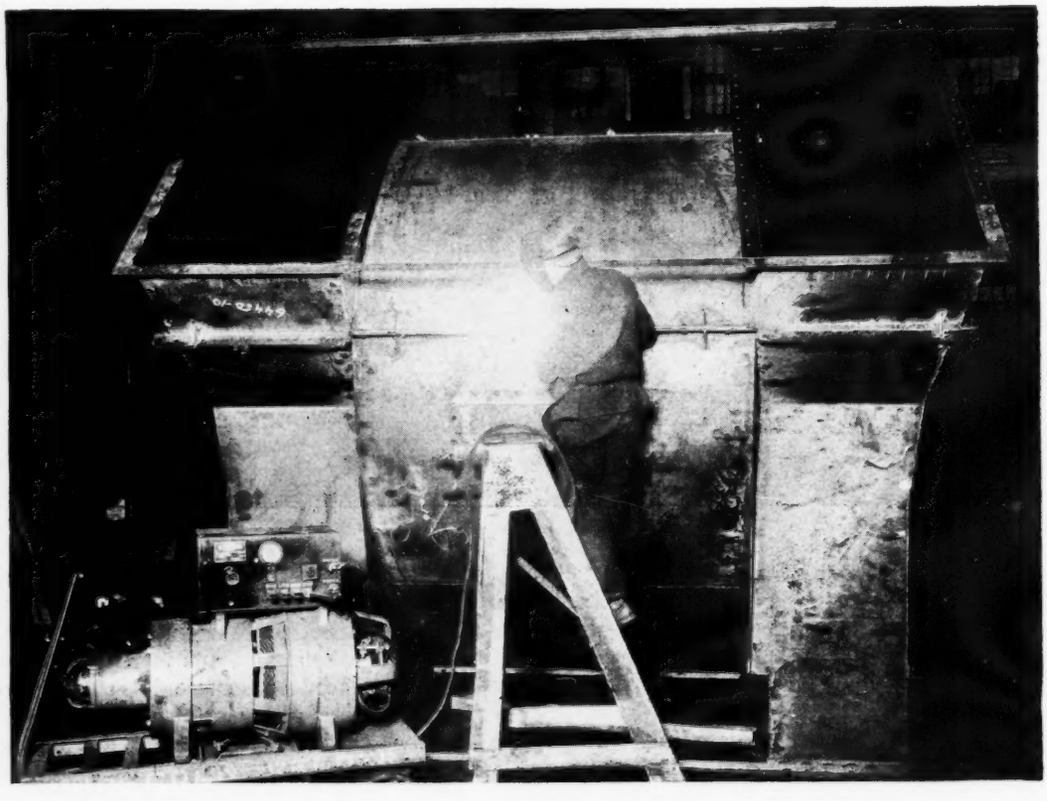


Fig. 3—Welding the casing of a high-speed forced-draft fan. Capacity 120,000 cu.ft. per second

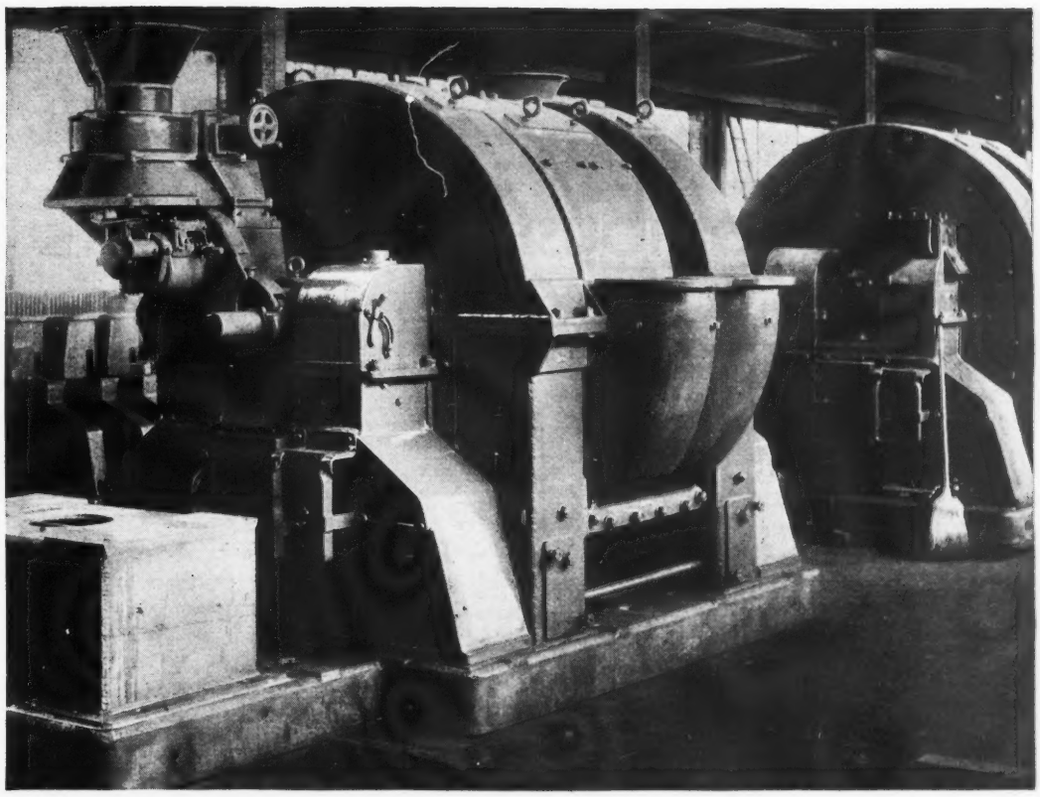


Fig. 4—Arc-welded duplex pulverizer, capacity 15,000 lb. per hour

lb. per hour and was designed for arc-welded steel construction by the Riley Stoker Company, of Worcester, Mass. The base of the pulverizer and the base of the driving motor, where the utmost in rigidity is required, are arc-welded steel. Bolts have been used only where interchangeability of parts is desired.

The same company considered the utility of the electric arc process in redesigning the burner shown in Fig. 1. The new burner, Fig. 2, was fabricated by arc welding.

A high-speed forced-draft fan manufactured by the American Blower Corporation is shown in the process of construction in Fig. 3. This fan is made entirely of $\frac{3}{16}$ in. steel plate and is designed to handle 120,000 cu.ft. of air per minute at a temperature of 100 deg. F. and a pressure of 5 in. of water. The fan operates at 850 r.p.m., has a housing which weighs 5,000 lb., a wheel weighing 1,750 lb. The shaft, which weighs 3,400 lb., has diameter of 10 inches.

Defective Safety Appliances Doubly Dangerous

NEGLECT OF SAFETY DEVICES in power plants is likely to convert them into instruments of danger. The mere presence of such devices cultivates a sense of security that makes them doubly dangerous when they are allowed to deteriorate to the point of giving uncertain action or none at all. As elsewhere, vigilance is the price of safety in a power plant.

An engineer in charge of a small factory power plant set a green hand to firing his one horizontal return-tubular boiler. Because of sediment's accumulating in the lower connection to the water column and so causing a false showing in the gage glass, the inexperienced fireman was deceived into letting the water fall below the level of the safety plugs. The plugs did not let go, and little damage resulted, for the danger was discovered and the fire pulled.

Investigation showed that the filling in the plugs was not pure tin. The presence of small percentages of lead and zinc was held responsible for the failure to blow. It was assumed that the impurities caused the filling gradually to acquire the properties of a metallic oxide. The fresh metal, if pure Banca tin, has a melting point close to 450 deg. F., but the oxide is impervious to the highest temperature ordinarily attained in a boiler furnace. But even a filling of pure tin needs watching. Both the water and fire ends of fusible plugs ought to be thoroughly cleaned every time the boiler is shut down.

To make sure that a safety device is in condition for instant service, it should be tested periodically, and the periods should not be too far apart. In many boiler plants it is a rule that safety valves shall be lifted from their seats at least once each day. The materials may be such that any chance of corrision's causing a continuously inactive valve to stick at a critical moment may be remote, but giving the valve a daily lift removes the danger altogether.

A good engine-stop comes close to being infallible against overspeed. Its office is to keep the engine from running away in the event of a sudden loss of load or disorder in the governing mechanism. In some forms centrifugal force puts the device into action, the activating force being overbalanced by the tension of a spring while the speed is below the danger point. With others the throttle valve is closed electrically when overspeed causes a tripping mechanism to work. In the one case the device is inoperative if the spring is too strong; in the other it fails if the electrical supply is cut off.

Combustion Chambers of American High-Speed Diesels

By EDGAR J. KATES
Consulting Engineer, New York

COMBUSTION chamber designs of American high-speed diesel engines show how many different solutions it is possible to find for one mechanical problem. At the present time all high-speed engines built in the United States employ mechanical, or airless, injection of fuel, and the function of the combustion chamber is to control the relative motion of the fuel and air to produce good mixing and insure satisfactory combustion. It is surprising how many different designs have been developed, all of which solve the problem in a more or less successful manner. To picture the designs more clearly it is worth while to group them into a few general types.

The form of classification of diesel engine combustion chambers suggested by a paper read a few months ago before the British Association by S. J. Davies and E. Giffen will be employed, although it is necessary to classify several designs as a combination of two types. In the chronological order of their conception the classes of combustion chambers are: Direct injection, or single chamber; antechamber, or pre-combustion; and auxiliary air chamber. These are shown in Fig. 1.

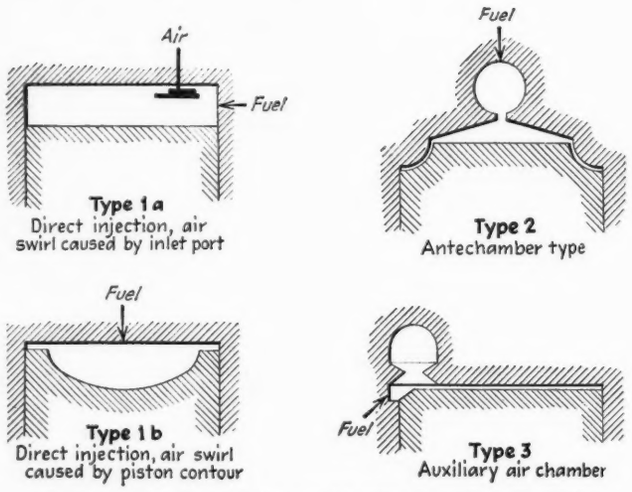


Fig. 1—The four basic combination chamber designs

Direct Injection or Single Chamber Type

The distinguishing feature of the direct injection system, is that the combustion chamber is an undivided space into which the fuel is directly injected in the form of a finely divided spray. The relative motion of air and fuel is accomplished by (*a*) air swirl caused by inlet port, or (*b*) air swirl produced by the piston contour.

By the first, or inlet-port, method combined with direct fuel injection, or Type *1a*, the incoming air is given a directional motion which continues throughout the compression stroke until the fuel is injected into it. The directional effect can be given to the incoming air in the inlet passages or at the inlet valve itself. For instance, in the De La Vergne 9x11 in. and the Packard airplane engines the inlet-valve ports are shaped to give a tangential swirl as the air enters the cylinder. The De La Vergne engine employes a four-valve cylinder head, while the Packard uses only one valve, which serves both inlet and exhaust. The Buda-M.A.N., on the other hand, employs the Hesselman design of shrouded inlet valve whereby a portion of the inlet valve circumference is blocked, thus causing the incoming air to take a definite direction through the remaining valve opening.

It is also possible to give directional motion to the air in a two-stroke-cycle engine having an undivided combustion chamber by suitably shaping the scavenging-air ports, but this has not been adopted in any commercial American high-speed engine.

Still another plan, which has been successfully developed by Ricardo in England, but not yet in use in the United States, employs a sleeve valve containing tangential ports which direct the air into the cylinder in a circular current.

In direct injection with air swirl caused by piston contour, Type *1b*, the shape of the air space changes as the piston approaches the cylinder head during the compression stroke, causing an air swirl which persists during the period of fuel injection. This piston swirl is easily accomplished in many designs by simply making a flat rim on the crown of the piston, so that when the piston approaches upper center it causes a rapid displacement of the air intrapped in the narrow clearance between the piston rim and the cylinder head. The resulting air movement produces uncontrolled turbulence as compared with the directed motion produced by Type

1a. Nevertheless, it is quite effective, and many American examples are to be found, such as Cooper-Bessemer, Westinghouse-Beardmore, and Winton. The Packard aircraft engine employs this system in combination with inlet-port air swirl.

In antechamber, or precombustion-chamber engines the combustion space is divided into two parts, the antechamber and the main space, separated by a constricted passage. The fuel is injected into the antechamber and is partly burned there. The resulting rise in pressure in the antechamber forcibly ejects the remaining fuel and hot gases into the main chamber, where the fuel mixes with the air and burns. The vigorous turbulence produced is not of the same definite character as the directed turbulence caused by inlet-port air swirl. It is very much like the turbulence produced in air-injected engines, but has the further advantage that the fuel is broken up by gases that are much hotter than the blast air-injection engines. Consequently, the fuel, when sprayed into the antechamber, need not be finely divided, and the fuel injection pressures in the antechamber engines are accordingly much lower than in single-chamber engines. American examples of high-speed antechamber design are the Fairbanks-Morse 6x6½-in. and the Hill 5x7-in. engines.

Auxiliary Air Chamber Type

The auxiliary air chamber, Type *2,* is often confused with the antechamber type because the combustion space is similarly divided into two parts separated by a constricted passage. There is, however, an important difference, as the fuel does not burn in the auxiliary air chamber, and, in fact, is not supposed even to enter it. During the compression stroke air is forced into the auxiliary air chamber, which acts simply as an air reservoir. Just before top dead center the fuel is injected into the passage connecting the air reservoir and the main combustion space, and combustion starts in the passage. As the piston moves down, the air flows rapidly out of the air reservoir both by pressure difference and by inertia effect, meeting the injected fuel in the passage. In other words, pure air for combustion is continually supplied to the burning fuel, and the products of combustion pass into the cylinder space. This design is particularly well adapted for operation over a wide range of speeds, since the higher the speed the greater the velocity of the air blast and the more rapid the combustion.

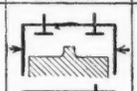
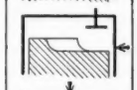
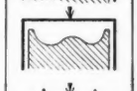
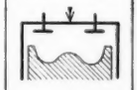
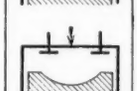
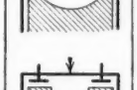
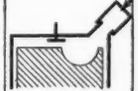
Engine	Type	Combustion Chamber	Cycle	Cylinder Dimensions	Rated R.P.M.
Buda - MAN	1a		4	6" x 8"	1,000
Packard	1a 1b		2	4 13/16" x 6"	1,950
De La Vergne	1a 1b		4	9" x 11"	750
Atlas Imperial Cooper Bessemer Winton Westinghouse	1b		4 4 4 4	7" x 8½" 7" x 9½" 8" x 10" 9" x 12"	650 500 750 900
Fulton - Foos Superior Speedway Standard Treiber	1b		4 4 4 4 4	8½" x 11" 8½" x 11" 8½" x 11" 6" x 8" 5" x 7"	750 600 700 1,000 1,200
McIntosh & Seymour	1b		4	9½" x 10½"	750
Hill	2		4	5" x 7"	1,000
Fairbanks Morse	2		2	6" x 6½"	800
Cummins			4	4½" x 6" 6¾" x 9"	900 800

Fig. 2—Classifications of combustion chambers of well-known American high-speed diesels

TABLE I—COMPARISON OF ADVANTAGES AND DISADVANTAGES OF THE VARIOUS TYPES OF COMBUSTION CHAMBERS

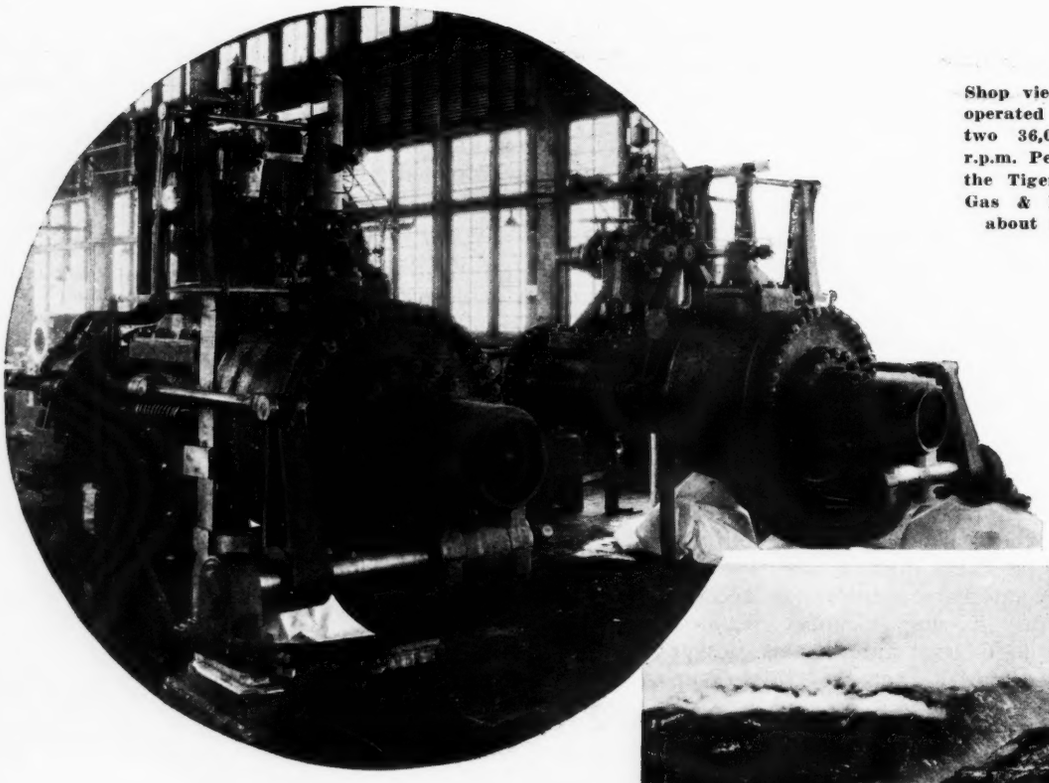
Type 1 Direct injection of single chamber.	Type 2 Antechamber of precombustion chamber.	Type 3 Auxiliary air chamber.
	ADVANTAGES	
Best thermal efficiency.	Low fuel injection pressure.	Low fuel injection pressure.
High mean effective pressures.	Inexpensive fuel injection system.	Inexpensive fuel injection system.
Start from cold without electric heating coils.	Can use fairly viscous fuels.	Can use fairly viscous fuels.
Simple cylinder head design.	.....	Better thermal efficiency and mean effective pressures than antechamber.
Maximum space for valves.	.....	
	DISADVANTAGES	
High fuel injection pressure. High cylinder pressure Sensitive to more viscous grades of fuel.	Greater surface volume ratio than in direct injection, hence greater loss of heat through jackets, lower thermal efficiency, lower mean effective pressures More difficulty in starting, requiring electric heating coils or higher compression	Lower thermal efficiency and mean effective pressure than direct injection. Requires electric heating coils or higher compression for quick starting.

In early designs the auxiliary air chamber was built into the piston, but this made the piston excessively heavy for high-speed work. The air reservoir now is formed inside the cylinder head, the air flow being due entirely to pressure difference. The best-known design is the Acro, used by Saurer in Switzerland and by the Associated Equipment Company in England. Auxiliary air chambers, however, are not used in American high-speed engines, except, in a partial way, in the Cummins engine, where they supplement direct injection with piston swirl, but this engine properly is classified as belonging to Type *1b.*

Table I summarizes the advantages and disadvantages of the various types of combustion chambers discussed.

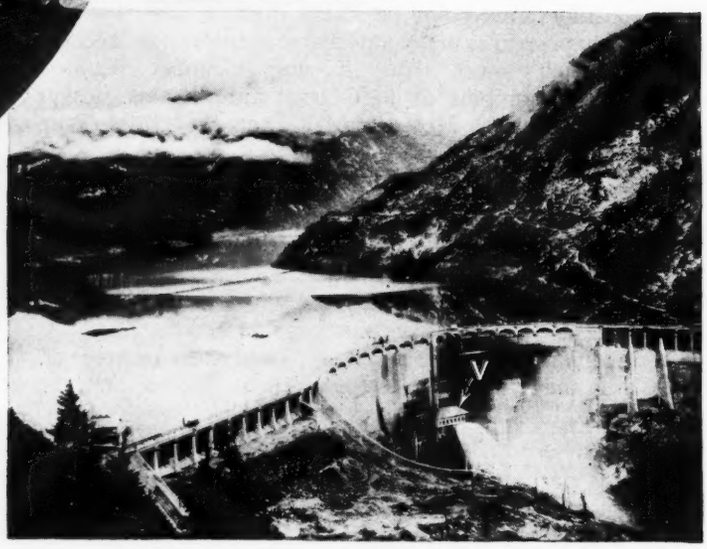
Most American engines use single combustion chambers, and of these the majority have piston crowns shaped to produce air swirl. It is not surprising that many American high-speed Diesel designs follow European practice, inasmuch as the high price of gasoline in Europe has long been an incentive to the development of diesel engines in automotive sizes.

It is a curious fact that many mechanical contrivances pass through three stages of design: First, the original conception in simple form; second, the design is improved in details and made considerably more complicated; finally the pendulum swings back and the machine again becomes highly simplified and also much superior to all previous forms. This is well illustrated by the development of the automotive gasoline engine, out of whose wide variety of forms 25 years ago has come the present standardization. The diesel engine, and particularly the high-speed diesel, is obviously in the second stage of development. Will all this diversification continue? Not if history repeats itself.



Shop view of nozzles with governor-operated needles and deflectors of the two 36,000-hp., 1,190-ft. head, 225-r.p.m. Pelton waterwheels installed in the Tiger Creek plant of the Pacific Gas & Electric Company, which is about ready for initial operation

HYDRO DEVELOPMENTS on the PACIFIC COAST



Diablo Dam of the city of Seattle on the Skagit River, Washington. In the valve house *V* are located three 78-in. Pelton, free-discharge butterfly valves and one 72-in. Larner Johnson free-discharge valve.

The 17-ft. main stop butterfly valve for the Ariel, Wash., development of the Inland Power & Light Company. This valve will operate under 180-ft. head. The valve's body is made in two parts and held together by the forged-steel shrink keys *L*

Photographs by courtesy of the Pelton Water Wheel Company, San Francisco, Calif.

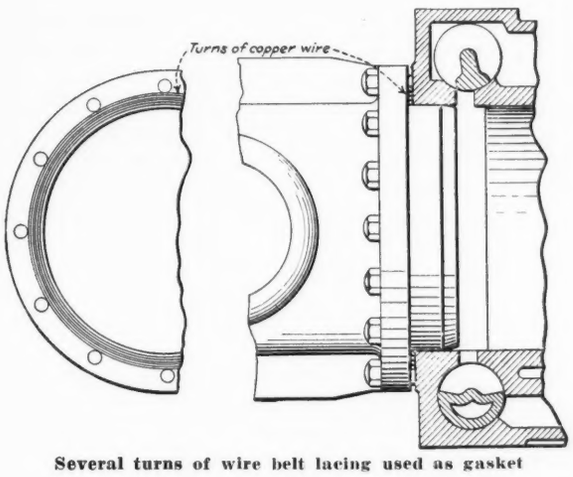
...RIGHT OUT OF THE PLANT...

Copper Wire for Cylinder-Head Gasket

IT MIGHT BE OF INTEREST to readers of *Power* to know how a bad situation was met when the crank-end cylinder-head gasket on a 28 x 48 in. corliss engine failed.

The time required to disconnect the steam and exhaust pipes, valve gear, piston rod, remove cylinder heads, pistons, anchor bolts, and crib up a suitable base on which to slide the cylinder (weighing approximately five tons) precluded the possibility of installing a sheet gasket of any kind, so it was decided to substitute copper wire.

By using the wire two men were able to do the job in two hours' time. All studs in the crank-end head were removed, and by the use of a screw jack the cylinder was pushed back about one inch to permit



Several turns of wire belt lacing used as gasket

cleaning the gasket faces with small hoe-like scrapers. The cylinder was then moved back into place with only sufficient space between gasket faces to insert a single strand of a special metallic belt lacing (soft copper wire). By the use of hacksaw blades this copper wire was worked down to the bottom of the space, one turn on top of the other, until nine turns were in, making nearly one inch in all.

The studs were then replaced and drawn up tight. It was found we had a tight joint, which has been in service over three years with no further attention.

The above repair was made at a total cost of $5, as compared to about $50 for the installation of a sheet gasket, which would have required at least 24 hr. time.

The copper wire should be pulled tight, as it is worked down in the space, to avoid any slack keeping the next turn from going down to the proper place.

This particular copper wire is very soft and it is slightly flattened when the studs are pulled tight.

Olympia, Wis. CURTIS L. OVERLY.

The Air Cushion in Belt Drives

ALL BELTS slip more or less on their pulleys, but few engineers realize the wear on the belts due to the slippage. They figure 1½ to 5 per cent slip in obtaining the velocity ratio of belted pulleys, and increase the size of the driving pulley correspondingly when correct speed is important. An allowance of 2 per cent for slip will generally be sufficient in millwork practice when using leather or canvas belting and plain cast-iron or plate pulleys. The slip is greatly reduced by using leather lagged or paper pulleys.

A better idea of the wear on a belt from slippage is obtained by consideration of a few figures. The most economical speed of belting is around 4,000 ft. per minute. Even at 1 per cent slip, this means 40 ft. per minute, 2,400 ft., per hour and over 3½ miles per eight-hour day. And the slip is often several times this amount.

When belts run at 4,500 ft. per minute and over the horsepower transmitted is decreased from theoretical estimates by the contrifugal action on the belting, which tends to form an air cushion between the belt and the pulley face.

Some engineers prefer light ply and wide belts on account of the better contact obtained by the more flexible belt; others prefer larger number of plies and a strainer pulley on the slack side. The tension on the belt is thus regulated and the belt runs smoother, since it is not so much affected by the slipping and gripping action that causes flapping of the belt. It has been proved by analyses and tests that the frictional contact that resists slipping between a belt and pulley varies with the tension, is independent of the area of the surfaces in contact, but increases with the angle on the pulley between the points where the belt goes on and off the pulley, which is the arc of contact. So it is evident that crosisng a belt, and thus increasing its arc of contact, will increase its frictional contact and hence its pulling power.

With open belts at high speed various forms of pulleys have been used to get rid of the air cushions, by perforations and grooves variously arranged.

Cilley, 1881, used grooves slanting from the rim to holes near the center. Shepherd (England), 1884, used groups of perforations, alternately arranged. Pocock (England), 1886, used grooves, circumferential, across, and slantingly criss-crossed on the face. Jones, 1890, continuous perforations. Dodge, 1891, rubber face transversely fluted and a fluted belt. Schevin, 1891, diagonal parallel grooves. Gould (England), 1892, polygonal

face with grooves. Tillison, 1897, reversely spiral grooves ending in central holes. Albert, 1902, transversely corrugated pressed steel rims. Ensign, 1903, reversely spiral grooves without holes. Baker, 1912, lagging with transverse grooves. Gardner, 1918, traction cups in the face. Williams, 1923, cross grooves beveled.

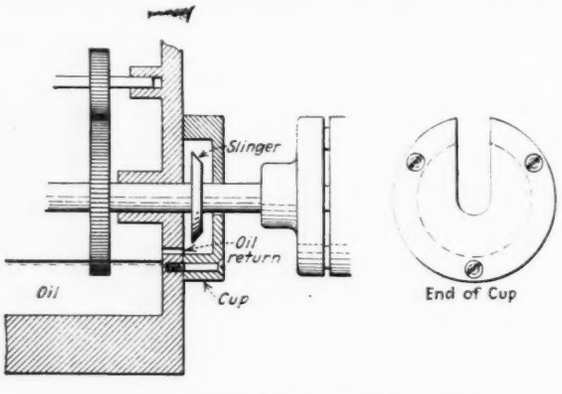
Although many have released the cushioning air by various perforations and grooves, few have given much attention to the form of the grooves. A square groove cutting the air at high speed plays various tunes. A series of tests on various forms showed that the "music" produced by a square groove was eliminated by slanting one face backward, and increased the tractive power of the belt. A later test on grooves with both faces meeting at 120 deg. showed increased efficiency over both the square and the slanting "V" form. Not only was the humming sound avoided but double the traction power was obtained.

The air currents from the approaching belt, driven against the revolving pulley, pass into and out of such beveled grooves instead of being carried onward under the belt, and this relatively backward flow of air causes a rarification in the groove that effects closer contact of belt and pulley face and consequently greater tractive power. I have tested such pulleys and know that greatly increased efficiency is secured by beveled grooves as stated. The foregoing theory followed this discovery, as that of the curve in baseball followed the actual demonstration of the curve after it had been previously declared illusory by scientists. H. M. PLAISTED.

St. Louis, Mo.

Eliminating Oil Drip on a Revolution Counter

THE DEVICE ILLUSTRATED effectively stopped an annoying creep of oil along the shaft of a revolution counter. As indicated in the sketch, the bearing extends from the back of the housing and is lubricated by the oil running off of a gear train. Before the addition of the slinger



Oil slinger on shaft of revolution counter

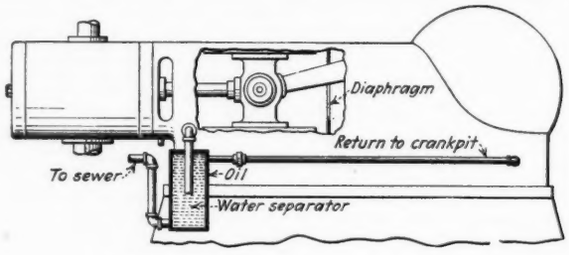
and cup the excess oil would creep along the shaft to the coupling, whence it would drop to the floor. The seepage now drips off of the slinger into the cup and is returned to the sump through a small hole drilled for that purpose. The slinger is pressed on to the shaft from the coupling end. B. F. POWELL.

Madison, N. J.

Trapping Leakage Through Cylinder Stuffing Box

AN ENGINEER in charge of a high-speed engine of the splash-oiled type found it difficult to keep the piston rod from carrying water of condensation from the cylinder into the guide barrel, whence it flowed into the crankpit. The result was a churning of the oil and water into a thick emulsion.

To remedy the difficulty the engineer spread a sheet-iron diaphragm across the crankcase between the guide barrel and crankpit and arranged to draw the oil and



Guide barrel drained to oil separator

water from the guide barrel into a separator, from which the oil returned to the crankpit and the water flowed away to the sewer. The details are shown in the accompanying sketch.

The diaphragm was made tight at the edges and a slot cut in it just large enough to give the connecting rod free action. The drain pipe leading from the guide barrel was tapped in just ahead of the rib that had been cast integrally with the frame to form a partition between the guide barrel and stuffing-box housing. Separate drainage of any water dripping directly from the stuffing box was thus possible. D. J. ALLISON.

St. Louis, Mo.

Writing In

THE FOREWORD entitled "Writing In" in the March 31 number was interesting to me, as it bring back vividly the memory of several personal experiences from which I have profited.

I have been contributing short articles to *Power* from time to time for about twenty years. Soon after having my first contributions published, I decided to write a (to my mind) masterpiece. I had, or rather thought I had, discovered a method of determining the maximum theoretical amount of CO_2 possible with any given fuel. It was a method so simple that anyone with a working knowledge of the multiplication tables could apply it. The more I worked on the idea, the more certain I became of its perfection. I worked up the data, wrote an enthusiastic description of the process and sent it in. I was sure that I had created something that would find its place in the front section of *Power*. But several weeks later it was returned with the usual polite little card of thanks and rejection; also, the editor had been kind enough to write me a note stating that he felt I had made a slight mistake in my reasoning, etc. Naturally, human-like, I was disappointed, and resolved to find out what the trouble was, with the result that I gave up the idea of discovering any new method, got a textbook and mastered the question. I then rewrote the article and sent

it again, but not to *Power* (I didn't have the nerve). It was accepted and published.

That one little incident taught me a lesson, from which I have profited many times. In the years that have followed, I have been called upon to write many reports and papers, sometimes upon subjects with which I was not familiar. I am sure that the success I have had with them is largely due to the experience and confidence my writing for publications has given me.

In order that one's contributions be accepted, they must be accurate, understandable and to the point. Their preparation improves one's knowledge of the subject because of the references and checking necessary. They tone up the reasoning faculties, and enlarge the power of expression. But, paramount of all, I believe, the self-confidence gained by the publication of an article is the greatest reward of all. By self-confidence, I do not mean conceit; self-confidence is the knowledge of one's true ability.

Norwalk, Calif. A. C. McHugh.

Misapplication of Engineering Terms

I was very much interested in the letter of D. J. Allison published in the May 12 number under the heading "Misapplication of Engineering Terms," because I have long been of the opinion that careless and conventional statements are the cause of a great deal of poor engineering.

Two of the worst offenders are the statements that "warm air rises" and "chimneys pull." Of course, warm air as well as everything else rises when there is a sufficient force operating upon it to counteract the force of gravity, but the force of gravity acts upon warm air in the same way as upon other things, and the direction of that force is *downward,* never upward.

The reason that, in many cases, warm air rises is because cold air falls and displaces the warmer, and lighter, air, which has nowhere to go but up.

Of course, this is all very elementary and everyone knows all about it, but, unfortunately, owing to a more or less universal habit of talking about warm air rising instead of the more basic phenomenon of cold air falling, a great many designers of heating and ventilating installations were quite obviously thinking about warm air rising instead of cold air falling when they laid out their work.

A large number of ventilating troubles will be found to be due to the fact that someone has overlooked the fact that cold air falls, and it is surprising what a lot of grief it will cause if it falls upon some man's bald head or upon some lady's lightly shod feet. In fact, we shall not go very far wrong if we paraphrase a familiar saying by asserting that if we take care of the cold air, the warm air will take care of itself.

It is quite surprising to find so many boiler breechings which have quite obviously been designed upon the assumption that chimneys pull. Chimney gases act, of course, in very much the same way as warm air. They are pushed up by the action of gravity on the heavier air outside the boiler and chimney.

Now if anyone thinks that this is mere quibbling, let him consider the difference between shooting a billiard ball through a breeching with a cue and pulling it through by a string attached to it.

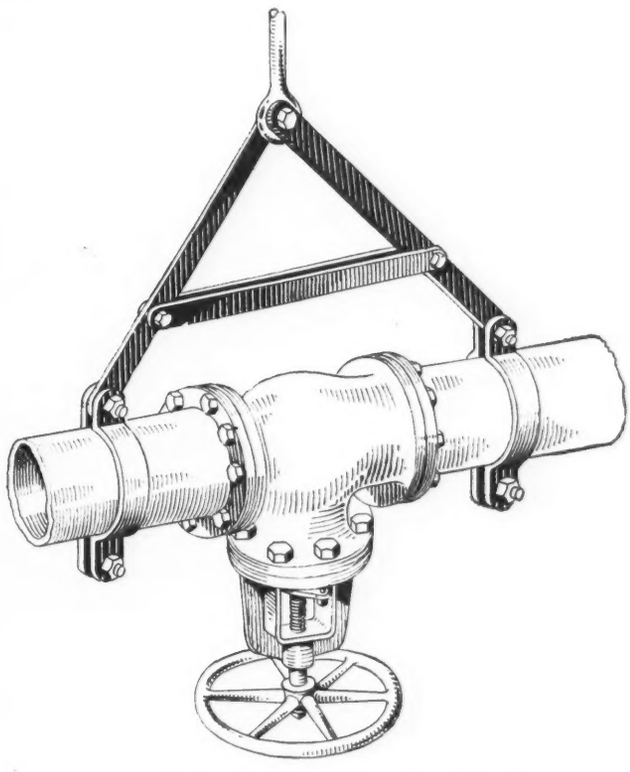
You could pull a billiard ball through almost any breeching, but there are very few through which you could shoot a ball even in theory. Perhaps it is too much to ask that all breechings should be so designed that a billiard ball could be shot through them, but if we find one which in most parts complies with this requirement, it is fairly safe to assume that it is a well-designed breeching.

While upon this subject, it will be well to keep in mind that CO and other heavy gases fall, and when designing breechings, care should be taken that these gases drain out and do not accumulate in pockets, to form explosive mixtures. James O. G. Gibbons,

Newark, N. J. *Consulting Engineer.*

Improved Design of Pipe Line Hanger Increases Stability

We were having some trouble with the joints of a 6 in. valve on one of the overhead steam lines and had to renew the joints frequently. This valve came at a section of the line where it was suspended from an overhead beam, and the hanger used was a single bar branching



Crossbars added to standard hanger give increased stability

downward into a vee and gripping the pipe on each side of the valve with clamps, a common type of hanger used about the plant.

Our maintenance man added the crossbars shown in the illustration, which not only cured any further trouble with the flange joints, but also added to the strength and ruggedness of the hanger. The hanger now supports the pipe line over a long length without any buckling and yet requires only one point of suspension from the roof or beam. C. W. Willey.

Concord, N. H.

From Among Readers' Problems

Conducted by
L. H. MORRISON

SHORT-CUT ESTIMATE OF EXCESS AIR—*Is there any rapid method of estimating excess air from CO_2 without recourse to tables or to the usual combustion formulas?* S.W.

For anthracite or low-volatile bituminous coal a rough estimate of the excess air can be made as follows:

Assume that total air supplied is represented by the figure 20 and the portion actually "burned" by the CO_2 percentage. Thus, if the CO_2 is 12 per cent, the air supplied is 20, that "burned" is 12 and the excess is $20 - 12 = 8$. Expressed in percentage the excess is

$$\frac{8}{12} \times 100 = 67 \text{ per cent.}$$

If the figure 19 is used instead of 20, this rule will work fairly well for high-volatile bituminous coals. It should never be used for oil or gas fuel.

The rule is theoretically exact, if the figure of 20.7 is used, when applied to a coal containing no volatile. This follows from the fact that air contains 20.7 per cent oxygen by volume and that the oxygen which combines with carbon produces an equal volume of CO_2.

—❖—

DETECTING LOOSE RIVETS IN BOILER DRUMS—*How can looseness of a boiler rivet be detected and how can it be corrected?* G.B.S.

A person experienced in making hammer tests usually can detect the presence of loose rivets in a boiler by striking the head with a sounding hammer. A loose rivet will be revealed by a marked difference in feeling the vibrations when the shell is struck a sharp hammer blow in the vicinity of the rivet. Looseness of a rivet in the shell usually is revealed by leakage.

In any case a loose rivet should be cut out, and after the rivet hole is reamed fair a hot rivet should be driven to fill the hole solidly. Leakage at a rivet sometimes may be stopped by calking, but when it is due to looseness at the rivet shank the calking will not hold it tight permanently.

—❖—

POUNDING OF FEED WATER PUMP—*We have considerable trouble from slip and pounding of our boiler-feed pump, which takes its suction from an open feed-water heater about 2 ft. above the pump. What is recommended?* R.C.A.

The most satisfactory remedy would be to set the pump 6 to 8 ft. lower or the heater that much higher to insure delivery of hot water to the pump, using a suction pipe at least as large as the connection on the pump.

Conditions may be such that the trouble would be remedied by simply placing an open stand pipe on a tee in the suction line close to the pump, making the standpipe and its connection at least the full size of the pump suction and extending the pipe about a foot above the height of the water level in the heater.

FOAMING AND PRIMING FROM SODA ASH—*Does soda ash in boiler feed cause foaming and priming?* A.D.W.

Soda ash of itself will not cause the trouble. When foaming occurs with the use of soda ash it usually will be found that proper provision is not made for removal of the precipitates, and priming and foaming result from the water's becoming fouled with impurities. Foaming may also occur from introduction of soda in an open heater that receives oil with the exhaust. The mixing of this oil with water containing soda ash results in a soapy emulsion that is favorable to foaming, which is made worse by the presence of precipitates of lime and magnesium compounds.

PREVIOUS QUESTION DISCUSSED BY READERS

THE QUESTION

MEGOHM METERS, which are widely used, apply voltages ranging from 500 to 1,000, depending on the instrument and the insulation being tested. What relation should the megohm meter's voltage bear to the rated voltage of the machine being tested? Has the insulation of apparatus tested been damaged by the use of a megohm meter? R.B.G.

THERE IS a 250-volt megohm meter on the market for use on machines rated up to 600 volts, but it is generally conceded to be better adapted to 110-volt equipment. I have never known of a case where a megohm meter's voltage damaged insulation, but for low-voltage equipment the low-voltage meter would answer the purpose just as well as the higher voltage one and would undoubtedly be safer, especially on old equipment.

Some of the modern test sets have a meter whereby the test generator voltage may be measured. If this meter is not incorporated in the megohm meter available, I advise turning the handle more slowly than ordinarily. This will lower the test voltage.

After the test is made at reduced voltage and the insulation shows a good reading the generator handle may be turned at full speed. For equipment up to 1,100 volts the 500-volt megohm meter may be used, but for all higher voltages the 1,000-volt meter is better. I do not recommend turning the generator at full speed on any equipment until a preliminary test is made with the generator turning at about half speed.

It is generally known that a test with high-voltage may weaken the insulation even though it stands the test. It is advisable to make a megohm-meter test before and after the voltage test. The first insulation-resistance test will indicate whether it is advisable to make the high-voltage test, and the second will show any weakness that might result from the high-voltage application.

If the machine's insulation is dirty it will be advisable to clean it before testing. When the windings are damp they should be dried, after which paint them with a high-grade insulating varnish. The test should not be made until the paint has become thoroughly dry.

The test voltage generally employed is twice operating voltage plus 1,000 and is much higher than the average megohm-meter voltage and may weaken the insulation. I should not advise a higher test voltage to ground for old equipment than its operating voltage. Generally if a machine will stand operating voltage to ground, and is then cleaned, dried and painted, it will give good service. As long as a machine is operating without undue maintenance costs and if a severe shutdown would not be caused by its failure, it is not always advisable to rewind or overhaul just because the insulation resistance is low. GRADY H. EMERSON.

Birmingham, Ala.

THERE ARE two distinct properties to any insulating material. Each of these may be determined by test. First, the insulation resistance is to be considered, and then the dielectric strength. The dielectric strength must be found by testing to destruction, which is done by raising the voltage impressed across the insulation until puncture occurs.

Present standards of the A.I.E.E. require that "the Standard Test Voltage for all machines except as otherwise specified shall be an alternating-current voltage at twice the rated voltage of the machine plus 1,000." This rule should be followed for new or expensive equipment where cost is secondary to 100 per cent service. After the equipment has been used some time the test voltage should be lower, so as not to cause unnecessary stress on the insulation.

To obtain correct readings of insulation resistance the megohm meter does not have to be as high as the rated voltage of the apparatus under test. If it is of the same voltage, and breakdown occurs, it is evident that this would have happened in service had the test not been made.

As to possibilities of damage to insulation by a megohm test, if the insulation is in such poor condition that its dielectric strength is down as low as its rated voltage, the use of the megohm meter will cause puncture.

H. M. SPRING.

Milford, N. J.

SECTION 7-500, "Standards of the American Institute of Electrical Engineers," under the heading "Dielectric Test," states that "the standard test for all machines, except as otherwise specified, shall be twice the rated voltage of the machine, plus 1,000 volts." Section 7-553, "Voltage for Insulation Resistance Test," specifies that, "insulation resistance tests shall, if possible, be made at a direct-current voltage of 500." Since the insulation resistance varies with the voltage, it is necessary that if a voltage other than 500 is to be employed in any case this other voltage be clearly specified.

The dielectric and insulation-resistance tests are made separately, the first generally with alternating current and the second always with direct current. The tests referred to above are manufacturer's or acceptance tests of the customers performed at the factory.

The dielectric test by the above rule will never be less than 1,000 volts, and I should say that apparatus of 100-volt service and up to 500-volt should be tested at 1,500 volts. This is the rule applied in wire testing by the Fire Underwriters, and the voltage is maintained for one minute, the insulation having been previously soaked in water for fifteen hours.

Insulation-resistance tests are generally made at below 1,000 volts, due to the difficulty of obtaining this voltage with direct current. In the insulated-wire business 100 volts is generally used with a sensitive galvanometer. It has been my experience that a high insulation-resistance value does not exclude dielectric or test-voltage failures. A low insulation resistance simply indicates that something is wrong, so that some of the short circuits may be avoided with high voltage. Moisture and leakage are important factors with this test, and everything possible should be done to eliminate them if a fair test is to be made.

The megohm-meter voltage bears no relation to the rated voltage of the apparatus. Generally the higher the meter's voltage the better the chance to find a fault, which is what the test is used for. Due to the design of the instrument the current is always small even with a short circuit, so that faults are not enlarged by the burning action of high currents.

Corona never forms at 1,000 volts, so the insulation is not damaged by this test. Corona forms at different voltages due to the shape of the electrified parts, but does not generally occur below 5,000 volts, regardless of shape. Corona acts on insulation by producing ozone, which deteriorates the insulating material.

Moisture, mechanical wear and chemicals generally cause more failures than voltages in the test range, that is, most failures are from physical defects, not voltage punctures.

P. CILLEY.

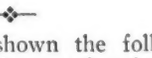
Salem, Mass.

THE MEGOHM METER VOLTAGE required depends on the capacity of the machine to be tested rather than on its voltage. Either 500- or 1,000-volt meters can be used, but with large-capacity machines it takes much longer to arrive at a steady reading with a 500 than with a 1,000-volt instrument. It might be said that for machines of 10,000-kva. capacity and below, use a 500-volt megohm meter, and for machines above that capacity use a 1,000-volt. The reading will be practically the same with either voltage, providing the megohm meter is applied sufficiently long to get a steady reading. However, for accurate comparisons the same voltage should be used.

Our experience would indicate that insulation is never damaged by using a megohm meter to test it. If the insulation is damp the megohm meter will give a zero reading, indicating practically a short circuit. However, upon drying out the insulation, it will be found in good condition if it originally had no defects. If the insulation is dry, 500 or 1,000 volts to ground is too low to do any damage.

J. LEECH-PORTER,

Canadian Westinghouse Co., Ltd.
Hamilton, Ont.



EXPERIENCE has shown the following relation between the rated voltage of the machine under test and the megohm meter's voltage to give the most satisfactory results: (1) a 500-volt megohm meter for all electrical equipment with a rated voltage of from 1 to 600 volts; (2) a 1,000-volt megohm meter for all electrical equipment with a rated voltage above 600 volts.

The A.I.E.E. standards state the following for the Voltage for Insulation Resistance Tests: "Insulation resistance tests shall, if possible, be made at a direct-current voltage of 500. Since the insulation resistance varies with the voltage, it is necessary that, if a voltage other than 500 is to be employed in any case, this other voltage shall be clearly specified."

The 500-volt megohm meter is available for a considerable range of insulation measurement and covers most requirements to which such portable testing instruments are applied.

The insulation of the apparatus tested is not damaged by the use of a megohm meter. Only a failure which occurs during the dielectric strength or "breakdown" test may damage the insulation at the point of failure. When this test exerts a static stress beyond the dielectric strength of the insulating material it causes an injury. The voltage range of the megohm meter is such that it is within the limit of the dielectric strength of the insulating materials used on modern electrical equipment. The megohm meter indicates only the resistance of the insulation; it does not exert a static stress. But a low insulation resistance value as obtained on a megohm meter indicates low dielectric strength and a possibility of failure of the insulating material due to high dielectric loss if a "breakdown" test were to be made upon this insulation while in this condition.

K. B. HOFFMAN.

West New York, N. J.

A Question for Our Readers

SOME of the squirrel-cage motors in our plant are giving trouble with loose connections between the rotor bars and end rings. The bars are bolted and soldered together. What is the best way to make these connections to prevent their working loose? R.E.H.

Suitable answers from readers will be paid for[1] and published in the Aug. 25 number

[1]As an alternative to cash payment for answers published, readers may select any one of the following books. (Be sure to state the book desired.):

Morrison's *American Diesel Engines*; Walker and Crocker's *Piping Handbook*; Norris and Therkeisen's *Heat Power*; Emswiler's *Thermodynamics*; Church's *Steam Turbines*; Uehling's *Heat Loss Analysis*; Croft's *Steam Power Plant Auxiliaries and Accessories*; Powell's *Boiler Feed Water Purification*; Osborne's *Power Plant Lubrication*; Moyer and Fritz' *Refrigeration*; Rietschel-Brabbee's *Heating and Ventilation*; Annett's *Electric Elevators*.

Application of Automatic Combustion Control*

By C. H. SANDERSON AND E. B. RICKETTS
The New York Edison Company

Reasons for using automatic combustion control and the methods of adapting it to the various types of boiler and auxiliary equipment. Some of the benefits obtained from the use of this type of control apparatus

SUCCESSFUL application of automatic devices to power-plant equipment for control of combustion has been very largely a development of the past ten years. During this period confidence in automatic operation was greatly strengthened by its success in other fields, particularly in electric substations and hydro-electric plants. Moreover, its development and application has had whole-hearted approval and assistance of engineers and operators because of the ever-increasing urge for higher efficiencies and lower fuel and labor costs.

Remote control of combustion equipment has become a necessity for the large modern boiler installations, for much the same reasons that necessitate its application to electric equipment. A boiler having a capacity of about 1,000,000 lb. of steam per hour may require as many as 8 controls, two for induced-draft fans, two for secondary fans, one for primary fan, two for excess-pressure valves, and one for fuel-feeder motors. This equipment is scattered over so wide an area that direct control would require six or eight men instead of one or two when all controls are concentrated at one point.

In a large modern power plant having a number of boilers, each with centralized hand control attended by two men, close regulation of combustion will often require their combined effort. It is usually impracticable, because of space requirements and the nature of the control, to concentrate it at one point. Therefore, the imagination will be put to little effort in visualizing the release of these men from a tedious and exacting service by the application of automatic control.

Development of the modern boiler plant necessitates consideration of large units, with the auxiliary equipment, in many cases, located 100 ft. or more from the control point, and the use of large stokers requiring varying air pressure in their different sections; the use of pulverized fuel, gas and oil, for which efficient operation requires closely coordinated regulation of fuel and air. The necessary complement of gages and meters for a single boiler has been very greatly increased; while, of economic necessity, the number of men has been reduced. The unit cost of labor and fuel has trebled in the last thirty years and consequently comparatively small savings in these items may justify the expenditure of considerable sums for new equipment to produce such results.

Reasons for Automatic Control

Because of the usually small amount of steam storage in boilers, fluctuations in station load are almost immediately reflected in steam demand. If maximum efficiency is to be consistently maintained these fluctuations in demand must be met by corresponding changes in fuel and air supply. When a multiplicity of boilers supply the steam system any change in station load should normally be divided evenly between them. If the operating force is sufficient in numbers, highly skilled and supplied with adequate instruments, results can be obtained with a well-planned manual control which compares favorably with the best automatic control. However, automatic control is ever alert to perform its functions, and its chief advantage lies in its ability to act simultaneously throughout the plant, thus permitting a reduction in the required number of skilled operators.

Large modern boiler installations are commonly equipped with push-button type of remote control, which represents probably the most easily and quickly manipulated type of manually operated equipment. The cost of such a system is a large portion of the cost of a complete automatic control system, as it may be incorporated as a part thereof.

Adapting the Control to the Installation

While control systems can be adapted to almost any type of boiler auxiliary equipment, the smoothness of operation is often complicated by the inherent characteristics of the apparatus controlled.

The ideal combination of control and auxiliary equipment is one which gives immediate response to a change in demand by delivering to the furnace a proportionately changed amount of fuel and air. Some types of equipment are inherently capable of approaching this ideal more closely than others, and an understanding of these characteristics will be helpful in realizing what may be accomplished with automatic control.

Air Supply—Air-supply control is usually actuated by draft at the boiler outlet. Some types of draft-producing equipment can be controlled in small increments; others operate with large increments.

Among the types of draft equipment producing smooth changes are: (1) chimney draft by damper control; (2) steam-driven fans by driver control; (3) direct-current motor-driven fans by driver control; (4) wound-rotor alternating-current motor-driven fans by driver control, and (5) single-speed alternating-current motor-driven fans by damper control.

Among the types of draft equipment producing abrupt changes of relatively large magnitude are: (1) multi-speed induction motor-driven fans by driver control; (2) multi-speed induction motor-driven fans by driver and damper control; and (3) multi-speed induction motor-driven fans by driver and vane control.

EFFECT OF LARGE, ABRUPT CHANGES IN AIR SUPPLY

Conditions	Effect
1. Stokers with deep fuel bed.	Smoke and temporary loss in efficiency.
2. Stokers with light fuel bed.	Blowing bare spots on grates, loss in efficiency and capacity over a considerable period.
3. Pulverized coal, bin and feeder system.	Possible loss of ignition.
4. Oil and gas.	Possible loss of ignition.
5. Pulverized coal, unit system.	Possible loss of ignition.

Large modern boiler installations employing long stokers commonly require a supply of air at several points at different pressures. This condition makes necessary the provision of several windbox pressure controllers, which may be adjusted either for a constant ratio or for varying ratios on the different sections of the stoker as the conditions may demand. Similarly, pulverized-fuel installations may require individual regulation of the primary-, secondary-, and tertiary-air pressures.

In most systems of control involving the supply of air for combustion under pressure it is necessary to provide an auxiliary control to prevent the occurrence of a pressure above atmosphere in the furnace. This control is actuated

*Abstract of a paper, "Automatic Combustion Control," presented at the Summer Convention of the American Institute of Electrical Engineers, Asheville, N. C., June 22 to 26, 1931.

by furnace draft and usually functions as an emergency or readjustment mechanism on the forced-draft fan.

Many different types of automatic control are available for application to the different systems used for producing draft or air supply. For example, in natural-draft installations the automatic control is usually applied to the stack damper. For adjustable-speed motors and steam turbines the speed of the driver only is automatically controlled.

In some unit pulverized-fuel systems it is necessary to introduce a time lag in the air-supply equipment to allow for the interval between the increase or decrease in the coal supply to the mill and the time when this change in supply reaches the furnace.

Air Measurement—In a few cases it is possible to measure the air supply by means of an orifice or some other metering device installed in the air-supply line. However, usually because considerable quantities of air enter through openings in the furnace setting, it is necessary to base the air control on the flow of the gases of combustion rather than the air supply. The medium most often used for this control is the pressure drop through a bank of boiler tubes. When the tubes are reasonably clean this method of air control is sufficiently accurate for all practical purposes.

When the tube bank becomes partly covered with slag, manual readjustment of the air-supply controller is necessary unless an additional control connection is made with some form of CO_2 meter to provide automatic readjustment.

Fuel Supply—Types of fuel-supply equipment have a very marked influence on the quickness of response to a change in load and on the effect on combustion conditions of large, abrupt changes in draft.

A. The following types of supply equipment afford immediate response:

1. Gas.
2. Oil.
3. Pulverized coal, bin and feeder system.
4. Stokers carrying a heavy fuel bed.

B. The following types have a slow response (from one to fifteen minutes):

1. Pulverized coal, unit system.
2. Stokers carrying a light fuel bed.

C. All types of fuel supply are adversely affected by large, abrupt changes in air supply, the disturbance in all cases being more marked with water-cooled furnaces than with refractory furnaces. The effect on some of the more widely used systems is shown in the table.

Fuel Measurement — Where coal is the fuel, its measurement is commonly derived from the revolutions of the fuel-feeding mechanism, each revolution of which is assumed to inject a given quantity of combustible material into the furnace. Unfortunately, however, coal is a product that may vary widely in physical and chemical characteristics, which are reflected in the fuel value per revolution of the feeding mechanism. Consequently, correct ratio of fuel and air can only be maintained either by occasional manual readjustment of the coal-feeding mechanism or by an automatic air-adjustment mechanism actuated by a CO_2 meter or a steam-flow air-flow meter.

Sequence Interlocking of Control—In nearly all large modern boiler installations it is necessary to provide sequence interlocking between certain of the control points. For example, it is usually necessary to provide that a shutdown of the induced-draft fan will simultaneously interrupt the coal feed and air supply and that the coal-feeding mechanism will not exceed the ability of the induced-draft fan to take away the products of combustion. In many installations employing pulverized-fuel firing there is a low limit below which combustion becomes unstable and a further reduction of coal and air feed may cause the fire to blow out.

Wherever automatic combustion control is applied, each boiler unit is provided with a simple and ready means for changing from automatic to hand control as necessary under emergency conditions, such as the interruption or partial interruption of the supply of coal, air or feed water to an individual boiler.

Control Power Supply — To insure continuous operation of the control system, the supply of the medium through which the control impulses are carried to the various regulators must be positively safeguarded by the provision of two or more independent sources of supply and a ready means of changing from one source to another.

Pneumatic and hydraulic systems were originally employed, but with the advent of electrically operated remote control, electricity has been adopted by a number of manufacturers as the medium for automatic control. The electrical control drives are designed to use either alternating or direct current at any voltage from 110 to 250.

Conclusion

The question is often asked, what financial return may be expected from an investment in automatic combustion control? The answer is infinitely more involved than the question.

Savings in operating expense as high as 4 per cent have been reported. Rarely, however, has it been found practicable to make comparative efficiency tests on the same installation operating with and without automatic control, to determine definitely the annual saving in operating expense.

As a rule, automatic control is seldom installed on the sole basis of a direct saving in operating expense. In fact, its installation is often based mainly on operating advantages otherwise difficult or even impossible of accomplishment. Among the more important of these advantages are, uniform loading of all boiler units; instant response to changes in load; supply of fuel and air in correct proportions at all times; ready means of providing for safety of operation through sequence interlocking of auxiliary equipment.

Obtaining Boiler Efficiency By Heat Balance

The value of obtaining boiler efficiency by heat balance calculations lies chiefly in the comparative ease with which the necessary test data may be obtained for making the calculations. Moreover, this method is peculiarly adaptable to Pacific Coast practice, where oil and gas fuels are used almost exclusively. In the case of coal there are a greater number of losses hard to determine accurately, such as the combustible in the refuse and flue dust.

Surprisingly accurate results may be obtained by the heat-balance method with oil or gas firing when exit flue gas temperature is measured correctly and a true sample of the flue gases is obtained for analysis. The temperature and analysis should be taken at the same place. Even the best-constructed boiler will have some air leakage into the system, for which reason the proportion of excess air is largest at the boiler outlet, and it would evidently be wrong for heat balance calculations to take flue gas samples at any other place than at the air heater outlet. All that it is necessary to know is the amount, temperature and composition of the flue gases leaving the boiler, so that the amount of heat rejected may be calculated. The principal losses in a gas or oil-fired boiler, where combustion is complete, consist of:

1. The loss due to the sensible heat above room temperature in the dry flue gases.
2. The loss due to the steam formed from the combustion of hydrogen in the fuel.
3. The loss due to radiation.

Other losses are usually very small and only a slight error will be introduced by neglecting them. If the three losses mentioned are expressed in B.t.u. per pound of fuel burned, the boiler efficiency may then be calculated with a very fair degree of accuracy as:

$$\textit{Boiler efficiency} = \frac{100\ (\textit{Item 1} + \textit{Item 2} + \textit{Item 3})}{\textit{B.t.u. per lb. of fuel}}$$

If proper care is taken in obtaining a true sample of flue gas, it is possible to keep the error in the final result within 1 per cent. Due to the fact that the losses in themselves are small, the error in the percentage of CO_2 due to improper sampling and analysis may run as high as 0.5 per cent, and the error in temperature measurement of the flue gas as high as 15 deg. F., without bringing the error in the final result above the value mentioned.—From report of sub-committee on heat balance and plant betterment, Pacific Coast Electrical Association.

▼

The new American Standard Safety Code for Coal Pneumatic Cleaning Plants (Z12f-1931) has been announced by the American Standards Association. Copies may be obtained at 10c. each from the A.S.A., 29 West 39th St., New York City.

Flow of Steam Through Orifice Into Heating-System Radiators*

By STERLING S. SANFORD and CARL B. SPRENGER
Detroit Edison Company

THE USE of a fixed orifice makes it possible to reduce the heat output of a radiator to any desired extent. It may be kept full of steam when the maximum heat output is needed, or in mild weather the flow of steam into the radiator may be reduced to such an extent, by reducing the difference in pressure between the two sides of the orifice, that only a small part of the radiator is heated. Between these extremes the pressure differential may be adjusted to give the flow of steam required for weather conditions encountered during the heating season.

Various ways of installing radiator orifices are shown in Fig. 1. At *A* a $\frac{3}{32}$-in. thick disk containing a straight-sided orifice is inserted in a recess cut in the radiator end of the valve tailpiece. The orifice at *B* is in a copper cup-shaped stamping 0.023 in. thick, and is

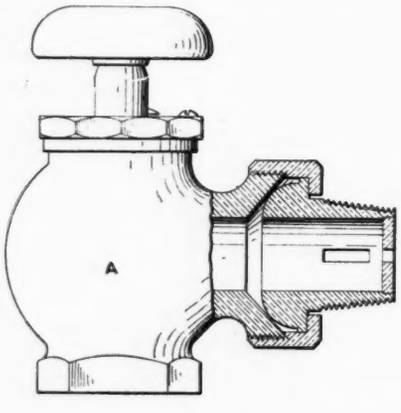


Fig. 1—Method of installing different types of radiator orifices

inserted in the union end of the tailpiece. The orifice at *C* is in a brass stamping 0.091 in. thick, shaped to form a gasket in the union.

Radiator orifices have been used in steam heating systems for many years, yet there have been published practically no reliable data on the flow of steam through them. Consequently, tests were made to determine the flow through different sizes of orifices, under various sets of conditions. The apparatus used

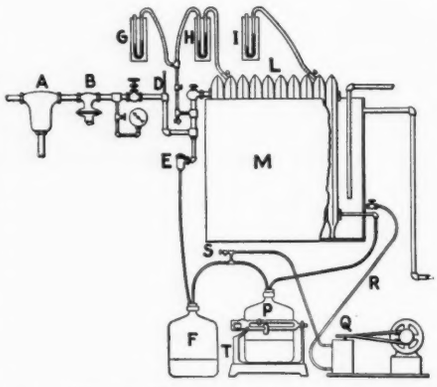


Fig. 2—Diagram of test set-up
A, steam separator; B, reducing valve; D, thermometer; E, thermostatic trap; F, bottle for collecting condensate from E; G, H, I, mercury manometer; L, radiator, 2 column, 10 section, 32 in. high; M, tank filled with cooling water; P, bottle for collecting condensate; Q, vacuum pump; S, needle valve for regulating vacuum; T, platform scales; R, water supply for air pump.

in making the tests is shown in Fig. 2. The flow of steam through the orifice was determined by weight. This was obtained by condensing the steam in a radiator surrounded by cold water, and collecting the condensate in a bottle on platform scale. With few exceptions, each test ran for one hour, during which the pressure on the inlet side of the radiator valve and in the radiator were held as nearly constant as possible. During the test at atmospheric pressure the radiator pressure was kept constant by venting the radiator to the atmosphere. During sub-atmospheric pressure tests the vacuum in the raditor was held constant by manipulating the needle valve *S*, varying the amount of air admitted to the air pump. In starting, the pressure was held constant for about 15 min. before taking the initial scale reading, thus allowing the temperature and other conditions to reach equilibrium.

Results of the tests on the orifices in the $\frac{3}{32}$-in. thick plates with atmospheric pressure on the radiator are indicated by the curves in Fig. 3, which shows the relation between steam flow and pressure drop through the orifice. When the pressure drop through the orifice is low, small changes in pressure affect the flow to a greater extent than do the changes in the region of high-pressure drop.

It should also be noted that the flow is not exactly proportional to the area. As the area of the orifice increases the rate of increase in flow decreases. Results of tests made with the orfice shown at *B*, Fig. 1, indicate the same flow characteristics obtained for orifice *A*, except that the flow is slightly reduced.

Tests were made to determine the effect of moving the orifice from one end of the valve tailpiece to the other. In every case the flow of steam was greater with the orifice installed in the union end of the tailpiece. This increased flow can be explained by the probable formation of a region of reduced pressure in the tailpiece surrounding the vena contracts.

Flow through a nozzle is given by the Moyer formula, $W = AP^{0.97} \div 60$. This formula holds only when the ratio of the final pressure to the initial pressure is less than 0.58. When the ratio of the final pressure to the initial pressure is greater than 0.58, the result given by the formula must be multiplied by a factor to obtain the actual flow. This factor is a function of the pressure ratio. The values for it, as determined by Rateau, are given by the upper curve in Fig. 4.

Flow Coefficient Compared

Flow through an orifice in the radiator is less than through a nozzle, and does not reach a maximum when the ratio of the final pressure to the initial pressure is 0.58. The flow continues to increase as the final pressure is reduced below 58 per cent of the initial pressure. The formula just discussed can also be used for calculating the flow through an orifice, if the proper coefficients are used with it. The lower curve in Fig. 4 gives the coefficient for an orifice in a thin plate as determined by Rateau.

The individual points on the curve are from the test reported. It will be noted that the points obtained from the test on the thin copper orifices agree closely with the curve given by Rateau, whereas the flow through the thicker orifice is somewhat greater, approaching that through a nozzle as the ratio of orifice diameter to thickness of plate increases.

In a heating system the pressure ahead of every radiator valve is not the same, because of the pressure drop in the piping, and, therefore, the flow of steam through the orifice into the

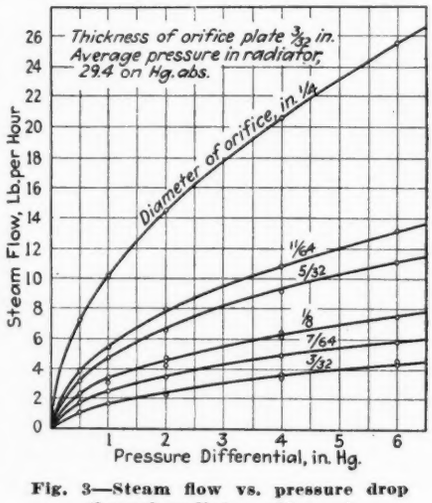


Fig. 3—Steam flow vs. pressure drop through radiator orifices of various diameter

*Abstract of paper presented at summer meeting of A.S.H.V.E.

TABLE I—SIZES OF "RADIATOR" ORIFICES

Orifice Diameter (In.)	Size of "Radiator" (Sq.Ft.)	Orifice Diameter (In.)	Size of "Radiator" (Sq.Ft.)
3/32	18	7/32	61
1/8	24	1/4	70
5/32	30	9/32	80
3/16	37	5/16	91
7/32	44	1/4	102
1/4	52	..	...

radiator nearest the source of supply will be greater than into the more distant radiators. This inequality of flow can be minimized by using small orifices, so that the pressure differential required across it to produce a given flow will be large compared with the pressure drop through the piping.

The allowable pressure drop through an orifice is limited by noise, which must not be loud enough to annoy room occupants. It has been found by experience that a pressure drop through the orifice of 6 in. of mercury can be used without causing annoyance. If the orifices are made of such a size that a pressure differential of 6 in. of mercury is required to keep the raditor full of steam under normal conditions, the sizes should be as given in Table 1, which is based on the use of orifice plates 3/32 in. thick located in the radiator end of the valve tailpiece.

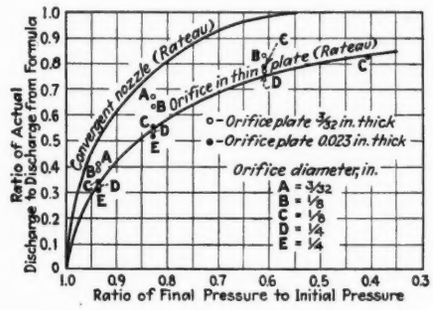

Ratio of Actual Discharge to Discharge from Formula
Ratio of Final Pressure to Initial Pressure
Convergent nozzle (Rateau)
Orifice in thin plate (Rateau)
o-Orifice plate 3/32 in. thick
•-Orifice plate 0.023 in. thick
Orifice diameter, in.
A = 3/32
B = 1/8
C = 1/8
D = 1/4
E = 1/4

Fig. 4—Values of coefficients for formula $W = AP^{0.97} \div 60$

If the total pressure drop in the piping between the first and last radiators of a heating system is high, the required flow of steam into the more distant radiators can be obtained by using larger orifices in these radiators. Another means of obtaining the desired steam flow into all of the radiators is to divide the heating system into zones, and to control the pressure in each zone independently.

The test data obtained has been based on the assumption that the system would be controlled by maintaining a constant pressure in the radiator, and by varying the pressure in the steam main. In vacuum systems, if desired, the steam pressure can be kept constant and the vacuum in the radiator varied to provide the required differential.

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EXPORTS of power generating machinery (except electrical) during the month of May, 1931, amounted to $1,884,522, as compared with $2,513,171 for May, 1930. Exports of electrical machinery for May of this year totaled $8,189,222, compared with $10,976,938 for the corresponding month last year.

Synthetic Lubricating Oils*

LUBRICATING oils are ordinarily manufactured from high-boiling fractions obtained in the distillation of crude oil. Certain undesirable constituents are removed in the refining operations to make salable products. Natural lubricating oils of different origin differ in properties, some excelling in one respect, others in other ways, but none combining to the fullest extent all desirable properties. It would seem that it should be possible to make an oil by chemical synthesis more closely approaching the ideal than any which could be produced from the mixtures which are combined in nature. The results of successful experiments with this objective in view were presented at a recent meeting of the American Chemical Society, by Sullivan, Voorhees, Neeley and Shankland of the research staff of the Standard Oil Company (Indiana).

Following up the clue that natural oils improve in certain characteristics as they approach the composition in which they contain two hydrogen atoms to each carbon atom, the investigators used pure olefines of this composition as starting materials. Olefines are constituents of petroleum containing hydrogen and carbon in this desired ratio, and have the property of combining readily with other bodies, or with themselves (the latter called polymerization). They may be either gases or liquids, and when they are treated with certain chemicals, aluminum chloride in the present instance, they are converted to higher-boiling, more-viscous liquids. By studying the properties of oils made from different kinds of olefines, it was found that the best oil resulted from the polymerization of olefines containing five to fifteen carbon atoms arranged in a straight chain. No such materials are available in pure form in commercial quantities. It was found, however, that when paraffin was "cracked" by heating it under pressure, the cracked distillate provided a satisfactory raw material. The olefines in this product were converted to heavy viscous oils by heating them with aluminum chloride. After this a simple refining operation yielded the oil.

Viscosity is the most important property of a lubricating oil, but, while oils of any desired viscosity at some standard temperature can be made from any kind of crude oil, the change of viscosity with temperature is a variable property with different oils. It is obviously desirable that, for the lubrication of mechanisms in which temperatures are not uniform or which are exposed to external variations in temperature, the minimum change of viscosity with temperature is desirable.

Solidification of oils is usually due to the separation of waxy solids which are removed to a greater or less degree during refining operations. The pour point is the lowest temperature at which the oil will flow, and determines, for instance, the minimum temperature for oil circulation in an automotive engine. Resistance to oxidation is also an important property.

The synthetic oils which are now available as a result of this development have an unusually low specific gravity and high flash point, and are very light colored. Since they contain no wax they flow at very low temperatures. Their viscosity changes less with temperature than that of any natural oil, thus making them particularly valuable where extremes of temperature are encountered in use. The resistance of the oils to sludge-forming oxidation is outstanding.

In the course of this research several oils have been discovered, varying in properties from those which are much worse than natural oils in certain respects to others which are far superior. Fortunately, it has been possible to develop the manufacture of synthetic oils of exceptionally high quality to a commercially practical operation, although, because of the involved manufacturing process, costs are necessarily higher than those of natural oils. Strangely enough, the most satisfactory raw material is wax, a byproduct which must be removed from natural lubricating fractions to produce satisfactory lubricating oils.

*Abstracted from the *Industrial Bulletin* of Arthur D. Little, Inc.

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Chinese Electrical Interests Organized

THE Association of Chinese Public Utility Corps, formed about two years ago, is probably the first organization of its kind in Chinese industrial history. During the brief period since its establishment, the association has been active both in the domestic and in the international circles. It became a member of the Union Internationale Producteurs et Distributeurs D'energie Eletrique last year. It sent representatives to the World Power Conference held at Berlin in May, 1930, and to this year's annual convention of the National Electric Light Association in Atlantic City, N. J.

The association includes private-owned electric light and power companies, electric traction companies and telephone companies. At present the majority of its members are from electric light and power companies, which represent more than 70 per cent of the whole industry in the country in terms of kilowatt capacity. There have been established more than ten branch associations in different provinces.

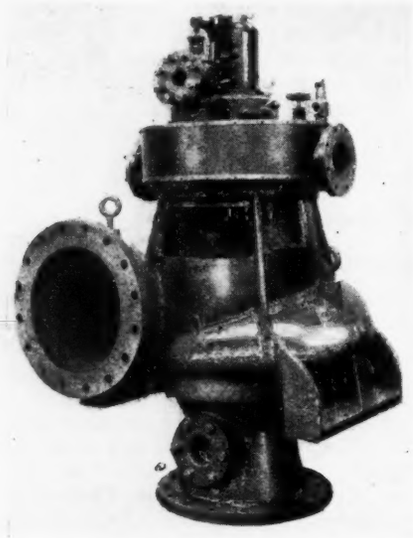
The association publishes a quarterly electrical magazine. It will hold its third annual convention, in Nanking, on Aug. 30. Its headquarters is at 21 Dah Za Poka, Nanking, China.

WHAT'S NEW IN PLANT EQUIPMENT

High-Speed Spiral Pumps for Stand-By Service

A HIGH-SPEED vertical spiral pump designed for handling large volumes of water at low head and particularly suited to stand-by service has been brought out by the Warren Steam Pump Company, Inc., Warren, Mass.

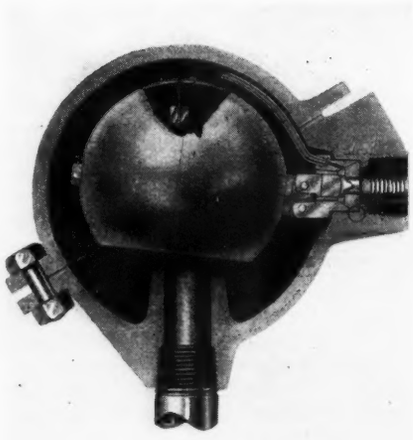
Although the pump is not designed to give as high efficiency as certain types of centrifugal pumps, it will operate at much higher speeds, which means a smaller unit over all and permits the use of a high-speed motor with its attendant lower cost. In the illustration the pump is shown connected to a steam turbine, but it is readily adaptable to motor drive.



Warren-Moody spiral pump

New Steam Trap With Spherical Body and Float

A "CANNONBALL" STEAM TRAP on the inverted-bucket principle has been announced recently by A. W. Holbrook & Sons, Inc., Palmer, Mass. The trap is built in the form of a sphere, as this geometric shape combines greatest cubic content and strength with least possible weight and bulk. The new trap discharges from the side of the body, permitting the removal of the cover without disturbing any piping. The vent hole in the bucket, which is common to all inverted bucket traps, is equipped with a cleaner. A piece of brass wire is weighted and hung through the vent hole so as to swing with each motion of the bucket. The wire cramps in the hole as it swings, preventing the formation of any stoppage.



Section of "Cannonball" steam trap

A three-way joint holds the valve seat in place and makes possible the complete removal of the mechanism as a unit. There are no threads on the valve seat, this being held in place by a two-stud type of gland, the bearing on which also supports the float and the bore of which serves as a valve guide. The trap is available in all sizes from ½ to 2 in. and for pressures up to 250 pounds.

Automatic Multiple Oiler With Gravity Feed

SIMPLICITY OF CONSTRUCTION and nonclogging are the principle features of the automatic multiple oiler announced by Gits Brothers Manufacturing Company, 1846 South Kilbourn Ave., Chicago. Controlled amounts of oil varying from ¼ to 10 drops are delivered by gravity to each bearing regardless of the viscosity of the oil, as long as it will flow through passages never less than $\frac{5}{16}$ in. Each oiler is made in eleven sizes having from two to twelve leads, and is intended to be located within 3 ft. of the bearings being lubricated.

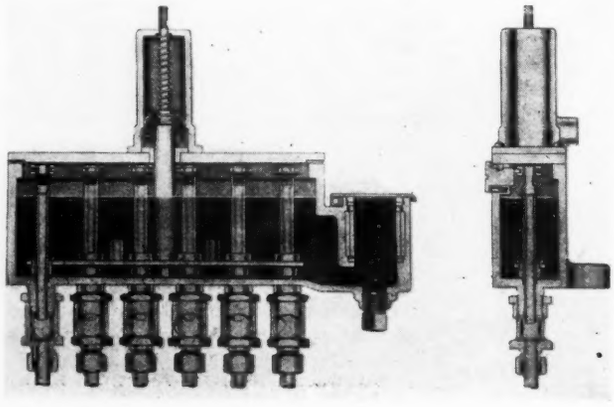
It is possible to operate as many as a hundred oilers simultaneously by compressed air from a single source, and where desirable a different grade of oil may be used in any one of them to suit particular conditions.

Operation can be by air, solenoid, electric motor, link connections to the machine being lubricated, or by hand. Whether this action is accomplished by air piston, solenoid or geared motor, a separate timing device is required suited to each type, but the timer is omitted if the oiler is operated mechanically.

These timing devices can be set to operate the oilers at intervals of 6, 12 and 24 min. or up to any interval that is necessary. In cases where three or four oilings a day are sufficient, hand operation is preferable. The timers can be driven by small electric motors or can be belted to the machine being lubricated.

The cross-sectional view shows a pneumatically operated oiler with six leads. Essentially, it consists of a piston and plunger with a crossbar to which six oil cups are attached. Ordinarily these cups rest in the bottom of a clear well of oil, but at selected intervals the crosshead is raised by the air piston to a fixed height and a quantity of oil in each cup discharged through standpipes connected directly to sight feed glasses below, whence the connection is made by tubing to the various bearings.

It is possible to operate the oiler by hand at any time or by a remote control switch independent of the timer, to flush the bearings initially—for example, when starting up. All oiler units are equipped with a sight gage and filling cap to show the oil level in the reservoir. The body is aluminum and the fittings brass. Copper tubing $\frac{5}{16}$ in. O.D. is usually furnished and is pushed into the bearing hole and held by a clamp.



Cross-section of the Gits automatic oiler, showing the simple arrangement of standpipes and feed cups

Improved Smoke Indicator

ELIMINATION of the time lag between the occurrence of the condition causing smoke and the actual indication of this condition is a feature of the Hannigan-McPherson smoke indicator introduced

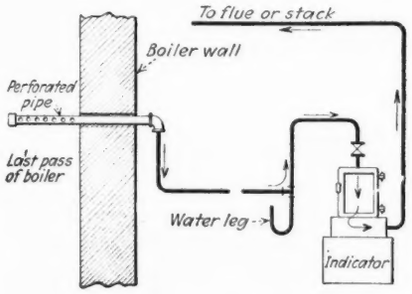


Fig. 1—How indicator is connected with the boiler

recently by C. D. McPherson, 5010 Duffield St., Frankford, Philadelphia, Pa. The use of this instrument enables the fireman to see the actual smoke before it reaches the breeching and to know almost instantly which boiler is producing the smoke.

The indicator is connected with the last pass of the boiler as indicated in Fig. 1, and a constant stream of flue gas is drawn through it by a motor-driven suction fan in the base section of the instrument.

The motor driving the fan is fully protected from dust and gas and is designed to require a minimum of attention. Motors can be supplied for either 110 or 220 volts, alternating current. When desired, an electrically operated alarm will be added to the indicator. This can be arranged to operate lights or bells, as required.

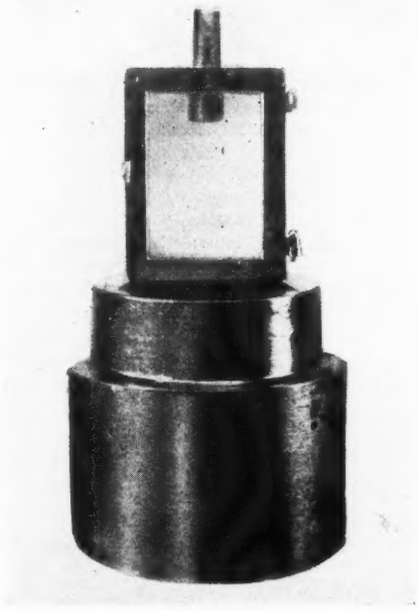
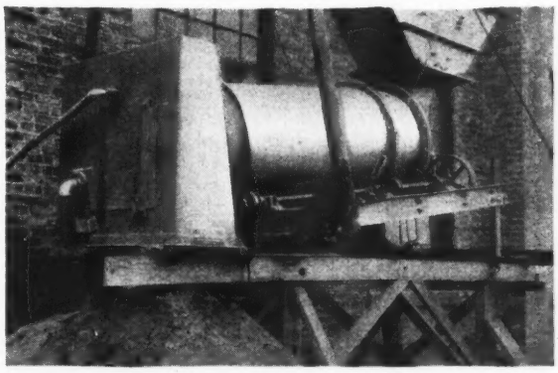


Fig. 2—Hannigan-McPherson smoke indicator

"Little Giant" screw extractor

Extractor for Broken Screws and Studs

FOR REMOVING broken screws, studs and pipe fittings the Greenfield Tap & Die Corporation, Greenfield, Mass., has announced the "Little Giant" screw extractor. The feature of this device is that it feeds itself into a hole drilled in the broken screw or stud, instead of having to be hammered in. This prevents expansion of the broken screw and jamming of the thread. The tool is made in diameters for the small end of $\frac{1}{16}$ to $1\frac{37}{32}$ inches.



In this inclined rotating drum fly ash is mixed thoroughly with water, then discharged in a loose but dustless condition

Mixing Equipment to Eliminate Fly Ash Dust

WITH THE GREAT INCREASE in the size of the modern steam-generating unit and the growth of the use of pulverized fuel the amount of fly ash to be handled in the modern power plant has grown to such volume that its disposal without the creation of objectionable and injurious dust has become a problem.

Successful steps have been taken to extract from the flue gases the fine dust that in the past has been permitted to escape from the stacks. Once collected this dust must be disposed of. If moisture is added to the fine dust when stored it settles and packs in the storage tank, so that its removal is laborious.

Furthermore, when the ash is stored wet, the storage tank must take up space inside the power house or must be provided with steam coils to prevent freezing. If the material is stored dry no trouble is experienced in discharging it from the storage tank, but the dust created in this operation may be objectionable.

Many methods have been tried to eliminate this dust, principal among which are telescopic chutes that can be lowered to the bottom of the car, the material being allowed to flow without any appreciable drop, canvas covers that fit over the truck or railroad car, inclined chutes of various kinds with water sprays placed within. Each of these has been used with some success, but none has completely eliminated the dust nuisance.

An entirely new type of mixing equipment for this purpose developed by the United Conveyor Corporation, Chicago, Ill., gives promise of a satisfactory solution to the problem of dustless handling of the fly ash. As shown in the illustration, the equipment consists of a large rotating steel drum, inclined toward the outlet end and provided with a series of water sprays and a scraper arm which extends the length of the drum.

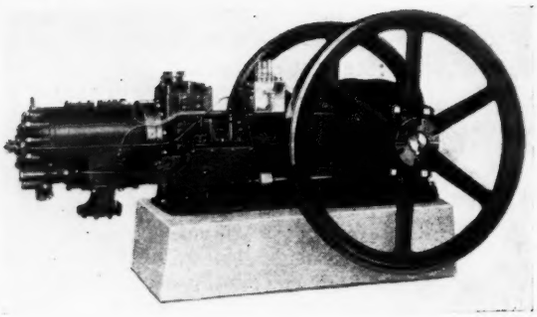
When ready to operate, turning the water on to the sprays automatically starts the motor, which drives the drum through a V-belt. This is accomplished by a mercury switch in the external arm of a swinging check valve in the water line. As ash is fed into the drum the moisture causes it to stick to the sides and be carried up on the shell until it is plowed off in a thin sheet by the scraper and caused to roll down to the bottom of the drum. During this operation the ash is sprayed constantly and thoroughly mixed with the water, so that it is discharged from the drum in a loose, fluffy, but entirely dustless, condition.

This equipment operates on about one-third the power required by a corresponding screw conveyor, uses a minimum amount of water, effects a thorough mixture of the water and the ash, and is subject to accurate control. At the completion of the operation the drum cleans itself of the ash, and owing to the fact that the scraper bar is held $\frac{1}{4}$ in. from the shell, the entire equipment is subject to little abrasion.

Two-Cycle Convertible Diesel Operates on Gas or Oil

ABILITY TO OPERATE on either oil or gas is a feature of the Type D.C. Diesel convertible engine brought out recently by the Joseph Reid Gas Engine Company, Oil City, Pa.

With a rating of 40 hp. at 275 r.p.m. the design of Type D.C. follows closely that of the Reid Type C gas engine. It is a solid-injection, two-stroke-cycle diesel having no mechanically operated valves. Two cylinder heads are used and the change from one fuel to the



Reid Type D.C. two-cycle stroke engine operates on either gas or oil

other is readily made by exchanging the heads, which, it is pointed out by the manufacturer, may be accomplished by two men in approximately one hour.

Maximum power ratings of the engine at 275 r.p.m. are given as, gas, 48 hp., and oil, 51 hp. The bore is $10\frac{3}{4}$ and the stroke 14 in. Maximum economy when producing 44 hp. at 275 r.p.m. is given as, gas, $11\frac{1}{2}$ cu.ft., and oil, 0.4 lb. per brake horsepower-hour.

Tandem System of Draft Gages for Zoned Air Flow Control

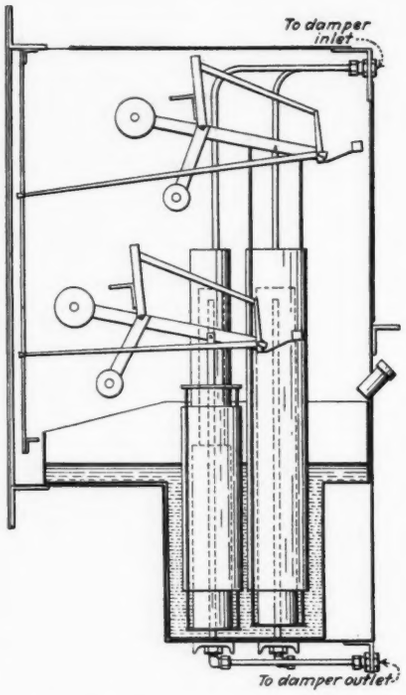
TO OBTAIN ADEQUATE CONTROL of the combustion process, the windbox under each retort of an underfeed stoker is divided into from two to four zones fitted with individual dampers through which the air flow may be measured and regulated. Likewise, the windbox under the extension grate is divided into several sections, usually the width of two or three retorts. The gages indicating the air flow through the damper, and the damper control rods, are mounted on a vertical panel so grouped into zones as to facilitate easy damper adjustment to maintain a desired or predetermined air flow to any zone or retort.

As an example of a typical requirement there is now under consideration a proposal to furnish zoned air flow control boards for underfeed stokers sixteen retorts wide. Specifications provide for four zones under the retorts and four divisions under the extension grate, requiring 68 air flow readings. To provide a compact gage with minimum space requirement, a tandem arrangement of differential elements has been devised by the Ellison Draft Gage Company, 214 West Kinzie St., Chicago, Ill. Standard movements, as furnished in the Ellison pointer draft gage with straight-line movement, are arranged in pairs, with two rows of pointers in the unit, one above the other in the same casing and with the bells one in back of the other in the same oil pan. Scale centers are $2\frac{3}{4}$ in., or an equivalent space requirement of $1\frac{3}{8}$ in. width for each reading.

With this arrangement a minimum of height is required, since seal provision for maximum static pressures of the lower forward row of elements likewise serves the upper row. Extension-type differential elements projecting above the beam are provided to afford protection against high induced-draft statics. The depth of the drop leg is dependent only on the maximum forced-draft static for which the gage is to be sealed.

All bells are served by a common oil pan or reservoir, provided with an oil filler in back of the gage through which the oil level may be seen on a marker. A drain is provided on the bottom of the pan and piped through the supporting plate in back of the casing. Pressure connections also are supported on the back of the casing, and shut-off cocks are furnished for each pipe line.

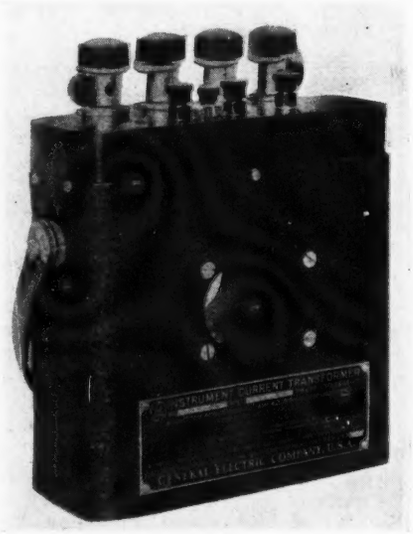
The usual range required is plus 1 in. of water differential, sealed as specified for maximum induced- and forced-draft statics. The scale for each pointer is 8 in. long, the two scales for each pair of pointers being combined in one piece. These scales may be furnished in square root graduations for direct indication of relative air flow, in uniformly spaced graduations, or graduated only at zero and full range. Movable markers consisting of a metal strip $\frac{1}{8}$ in. wide across the scale are provided for adjusting pressure curves on the scales.



Ellison pointer draft gage with straight-line movement arranged in tandem system for zoned air flow

Portable Current Transformer for Testing

THIS MULTI-RANGE portable current transformer for general-purpose testing has ratings up to 1,100 amp., in a series of eleven steps. The secondary rating is 5 amp. It is suitable for use on 2,500-volt, 25-to-125 cycle circuits. The transformer is designated Type PR-1



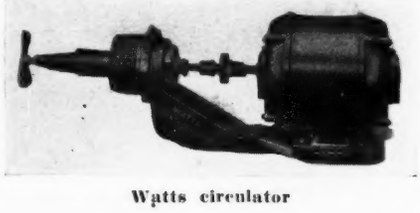
Transformer for general-purpose testing

and measures $3\frac{5}{8}$ in x $9\frac{1}{4}$ in., with a height over terminals of $9\frac{7}{8}$ in., weighing only 13 lb. The core and windings are firmly attached to the cover, which is easily removed for inspection. It is put out by the General Electric Company, Schenectady, N. Y.

Propeller-Type Water Circulator

ALTHOUGH DESIGNED, primarily, for use with hot-water heating systems as a means of eliminating sluggish circulation and improving the efficiency of a system, the circulator illustrated is suitable for practically any circulating service where light liquids are used.

The unit is made to screw into an opening in a standard pipe fitting and is supported in proper operating position by the pipe fitting. The circulator is made in three sizes, which can be readily adjusted for all pipe sizes from $1\frac{1}{2}$ to 5 in. Approximate capacity ratings for the three sizes range from 750 to 14,000 gal. per hour. The circulator is put out by the Watts Regulator Company, Lawrence, Mass.



Watts circulator

NEWS of the FIELD

Fusion-Welded Drums Authorized by A. S. M. E. Boiler Code Committee

New code result of ten years of study and discussion provides also for three classes of pressure vessels

AFTER ten years of study and discussion, power boiler drums, fabricated by fusion welding, have been authorized by the Boiler Code Committee of the American Society of Mechanical Engineers. Extensive code revisions covering boiler drums and other pressure vessels were adopted by the Committee on June 27 and approved by the Council's Executive Committee July 7.

This welding code is in substantial accord with tentative codes presented for discussion in recent months. One distinct change, however, from earlier proposals is the elimination of the grading of welding as A, B, C, etc. The classification of pressure vessels was retained, the present code covering class 1, class 2 and class 3. For each of these classifications the welding requirements are specifically outlined, thus retaining in actuality the grades of welding without so designating them.

In its final authorized form, the code for power boiler drums is practically identical with that for Class 1 pressure vessels, although the code does not include boiler drums in Class 1 vessels, as was done in earlier proposals.

Classification Provisions

Class 1 vessels may be used for any purpose without restriction. Vessels made in accordance with the specifications for Class 2 may be used for any purpose except for holding lethal gases or liquids, or holding any liquids at a temperature of 300 deg. F. or above. The maximum pressure at which any vessel in this class may be operated is 400 lb., and the maximum temperature, 700 deg. F. The maximum plate thickness is 1½ in.

Class 3 includes all vessels covered by this code not exceeding ⅝-in. plate thickness, and used for the storage of gases or liquids at temperatures not materially exceeding their boiling temperature at atmospheric pressure, and at pressures not to exceed 200 lb., or temperature not to exceed 250 deg. F., and providing also that the gases or liquids are not lethal.

In the face of a substantial opposition, the Code Committee retained, for Class 1 vessels and for boiler drums, the requirements of X-ray examination and stress release by over-all heating. The committee rejected the suggestion that stress release by mechanical means be permitted. It had been proposed to stress the metal up to the yield point by internal pressure, thus relieving internal stresses.

The history of the welding code has involved many conflicts of opinions and of interests. The matter was first agitated ten years ago, but not until July 6, 1931 has the A.S.M.E. Boiler Code permitted welding of any part of a power boiler where strength of the structure was dependent on the weld.

Evolution of Code

During this ten-year period codes on the fusion welding of unfired pressure vessels were developed to a limited extent, but no adequate provision was made for the wide range of service requirements in this field. During this period there was no relaxation of the original requirement that boiler drum welds should not carry stress essential to the strength of the structure.

Some three years ago the Boiler Code Committee enlisted the cooperation of the American Welding Society, and thereby made available a great body of specialized knowledge on this subject.

But even with this aid it was found necessary to prepare many tentative codes before one of sufficient general acceptability could be found. Even the code actually adopted will undoubtedly encounter criticism from those who feel that X-ray testing and overall stress release by heating are undue burdens on manufacturers, particularly the smaller manufacturers who must make a substantial investment in the necessary X-ray apparatus and annealing oven. The Code Committee feels, however, that these burdens are necessary at present to protect the public safety.

Without going into details, the code requirements for fusion welded boiler drums may be outlined as follows:

The joint efficiency shall be taken as 90 per cent. Test plates shall be prepared by continuing the weld at each end of the drum to join test pieces of similar construction. From one of these test plates are taken the coupons for tension and bent tests, and for specific gravity determination.

One tensile specimen is used to measure the strength of the joint, and the other that of the weld metal. The bend test specimen, transverse to the welded joint, must show a fibre elongation of 30% without cracking. The minimum specific gravity of the weld metal shall be 7.80.

X-ray tests are required for plate thicknesses of 3 in. and less. Every portion of all longitudinal and circumferential welded joints of the structure must be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 per cent of the thickness of the base plate.

On the basis that practical apparatus is not available for plates of greater thickness, the committee does not require them to be X-rayed at the present time, but does require that a manufacturer desiring to build drums of such thicknesses demonstrate by the X-ray his ability to produce sound welds in shells of a thickness of not less than 2½ in.

The code leaves a loophole for the use of other methods of non-destructive testing, with the phrase, "Any approved equivalent method may be used."

Both longitudinal and circumferential joints must be of the double-welded butt type reinforced on both sides. Nozzles, according to the code, may be fusion-welded.

Heat Treatment Required

The stress relieving requirements provide that the shell shall be heated uniformly to at least 1,100 deg. F., and up to 1,200 deg. F., or higher, if this can be done without distortion. The structure, or parts of the structure, are then brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and then allowed to cool in a still atmosphere.

This heating may be done on the complete vessel as a unit, or section by section before attachment to other sections of the vessel. In places where the vessel is stress relieved in sections, it is required that the final girth joints be stress relieved by heating uniformly a circumferential band having a minimum width six times the plate thickness on each side of the welded seam.

St. Lawrence Waterway Treaty May Be Handled by Diplomatic Representatives

NEGOTIATION of the treaty for undertaking construction of the St. Lawrence waterway through the diplomatic representatives of the United States and Canada, rather than through a joint commission appointed for the purpose has not been officially confirmed but appears to be probable. This government leans to the commission plan of negotiation but President Hoover is not likely to quibble on the manner of approach if the Dominion government feels that direct negotiation is the quickest means to an agreement that will permit the work to go ahead.

It is understood that William Duncan Herridge made the suggestion to Secretary of State Stimson immediately after the new Canadian minister had presented his credentials at the White House. Major Herridge is Premier Bennett's brother-in-law and his intimate knowledge of the conservative leader's views augurs well for speedy agreement by direct handling of a project involving aspects that cannot finally be disposed of by engineers.

The joint engineering board has reached substantial accord and the decision whether there shall be a one-stage or two-stage development, although fundamentally an engineering problem, has political implications that would be much less formidable and more quickly reconciled by Major Herridge and Hanford J. MacNeider, the American minister, than by a large board of commissioners, that collectively are not so sensitive to the attitude of their principals, and do not have as much freedom of action.

That Canada is ready to proceed without further delay is confirmed by the report that Major Herridge has been given full authority by Premier Bennett to initiate the negotiations. It is understood that Canada believes the present to be a favorable time to seek agreement on the project. This is in harmony with President Hoover's desire to conclude a treaty that may be presented to the Senate next December for ratification.

Announce Membership of A.S.M.E. Pure Air Committee

THE PERSONNEL of the Pure Air Committee recently organized by the American Society of Mechanical Engineers was announced last week by Ely C. Hutchinson, chairman of the committee. Besides Mr. Hutchinson, the new body comprises Col. Elliott H. Whitlock, secretary, research professor of mechanical engineering at Stevens Institute of Technology; H. K. Kugel, smoke commissioner of the City of Cleveland; Victor J. Azbe, consulting engineer of St. Louis, Mo.; and O. P. Hood, chief of the technical branch of the United States Bureau of Mines, Washington, D. C. More members may be added in the future as the work of the committee requires, Mr. Hutchinson stated.

Representatives of cooperating organizations on the committee include E. B. Ricketts, National Electric Light Association; H. B. Meller, The Mellon Institute; and Philip Drinker, American Society of Heating and Ventilating Engineers.

The committee was formed, it is stated, to give engineering recognition to the problem of air purification and to encourage and cooperate with all agencies working for the abatement of the smoke nuisance.

Missouri Court Decides Against Instalment Buying

DECLARING that the city had exceeded its legal debt limit, the Missouri Supreme Court has just ruled against a contract between Harrisonville, Mo., and Fairbanks, Morse & Company for the purchase of equipment for a municipal light and power plant to be paid for out of the plant's earnings in 60 monthly instalments. Plaintiffs in the case were the Missouri Public Service Company and several taxpayers of the city.

The court ruled against the contract on the ground that one of its provisions, requiring the city to pay for electricity used for municipal purposes until the machinery was paid for, created a general obligation against tax funds, and that as a result the city had exceeded its legal debt limit, which had already been reached prior to signing the contract.

The present ruling, however, does not reverse the decision of the Missouri Supreme Court in the Fayette case over a year ago, in which the city's contract for the purchase of equipment for its power plant out of earnings on an instalment plan was sustained. In that case, the court held the contract valid on the ground that the constitutional limitation applied only to debts which had to be met from taxes and that the contract in question could be met without the need of resorting to taxation.

Time Extension Granted on Hoover Dam Power Contracts

AN EXTENSION of four months' time in which to ratify Hoover Dam power contracts with the government has been granted Pasadena, Calif., and ten other allottees by Dr. Ray Lyman Wilbur, Secretary of the Interior, according to Harold P. Huls, Pasadena city attorney and chairman of the legal committee of smaller city allottees. Other cities in this group are Burbank, Glendale, Beverly Hills, Fullerton, Anaheim, Newport Beach, Riverside, Colton, Santa Ana and San Bernardino, as originally designated. In the original allocation of power by contract of April 26, 1930, cities in Southern California other than Los Angeles were allocated six per cent of the power to be generated, or 39,000 horsepower.

Announcement was made by Mr. Huls that Hoover Dam power contracts of the smaller allottee cities may be signed at any time now, but will not be binding unless ratified by a two-thirds vote of the electors of the interested communities on or before Nov. 15, 1931.

Ross Reinstated as Seattle Voters Recall Mayor Edwards

FOLLOWING the recall of Mayor Frank Edwards, of Seattle, Wash., at a city election held on July 13, the City Council reinstated J. D. Ross as superintendent of the municipal lighting department. He succeeds W. Chester Morse, city engineer under Mayor Bertha K. Landes, who was named light superintendent by Mr. Edwards on May 4.

Charges of incompetency, devolving in part around the dismissal of Mr. Ross on March 9, preceded the election in which Mayor Edwards was recalled by a vote of 35,657 to 21,836. Following the recall the City Council chose its president, Robert H. Harlin, to serve as mayor until another election is held.

Mr. Ross, until he was dismissed by Mayor Edwards, had served as head of the municipal lighting department for 25 years. On being restored to his post, he said, "The success of the recall serves notice on friends and foes of public ownership that Seattle is definitely committed to protection and progress of its city-owned utility. City Light can now go on to greater things with its future and credit safer after this election."

Heating and Ventilating Show Planned for 1932

WITH OVER HALF of its exhibit space already sold, the Second International Heating and Ventilating Exposition, to be held in Cleveland, Ohio, Jan. 25-29, 1932, in conjunction with the annual meetings of the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers, is well on its way to duplicate and even surpass the success of the 1930 Show in Philadelphia, it is announced.

The exposition will embrace separate sections, one for the heating and ven-

tilating industry in general, an oil burner section, a gas section, and a warm air section. In addition to the endorsement of the A.S.H.V.E., the exposition will have the active support of the American Oil Burner Association and the A.S.R.E. All three of these organizations will have booths at the show, making it in fact representative of every branch of heating and ventilation. As in Philadelphia, a feature of the show will be the display in full operation of coal, gas and oil burning equipment.

Fan and Unit Heater Sales Reported by Census Bureau

THE BUREAU OF THE CENSUS has started compiling detailed statistics on the value of orders booked for fans and unit heaters produced by manufacturers in this country. The first release covers the month of May, 1931, and is based on data reported by 26 manufacturers whose production, it is estimated, represents 85 per cent of the total. The bureau proposes to publish in future releases comparable statistics from month to month, beginning with Jan., 1931, if complete data can be obtained.

According to the release for May, total sales of fans and unit heaters during that month amounted to $1,459,876. Of this sales of fans for public buildings totaled $165,196; fans for general industrial use, $150,492; and mechanical draft fans, $81,097. Industrial unit heater sales were $151,115; school unit heaters, $284,441; and air washers, $56,352. Orders for indirect heating surface, not including unit heater surface, were as follows: Steel pipe coil type, $5,635; cast iron type, $10,942; and copper or aluminum type, $114,903. Driving mechanism sold for general fan use included $100,742 for electric motors, $3,469 for steam engines and $27,047 for steam turbines.

Joint Board Appointed to Prepare Muscle Shoals Plan

FOLLOWING up his own suggestion in the veto message on the Muscle Shoals operation bill, President Hoover on July 14 appointed Edward A. O'Neal of Alabama, president of the American Farm Bureau Federation; Col. Harley B. Ferguson of the Army Engineers, and Col. Joseph I. McMullen of the Judge Advocate-General's Department to represent the Federal Government on a joint federal and state commission to determine a method for handling the power and nitrate plants on the Tennessee River.

The governors of Alabama and Tennessee, the states most vitally affected by the disposition of the Muscle Shoals plants, have already designated their representatives, under legislative authorization, as follows: Alabama will be represented by W. F. McFarland of Florence, J. N. Duncan of Auburn and S. F. Hobbs of Selma, and Tennessee by Mercer Reynolds of Chattanooga, Vance J. Alexander of Nashville and W. A. Caldwell of Jackson.

The Muscle Shoals Commission is expected to devise some plan for handling the power properties, to be presented to the next Congress, which assembles in December. The administration hopes to have a well-developed proposal, carrying with it the backing of the communities surrounding the dam site, in place of the bills on the subject which have been brought up in the legislative branch in the past ten years.

N.E.L.A. to Hold 1932 Meeting in Atlantic City

ATLANTIC CITY has been chosen as the convention city for the exhibit and 55th convention of the National Electric Light Association to be held on June 6 to 10, 1932. This announcement was made July 13 by Paul S. Clapp, managing director of the association, following a decision of the officers of the association who were elected at the 54th convention in Atlantic City last month. As in the past the meeting and exhibit will be held in the municipal auditorium and convention hall.

News of Canada

Seven Sisters, La Gabelle and Slave Falls ready for service—Start survey for 400,000-hp. Manitoba plant

MANITOBA'S largest hydro power project, namely the Seven Sisters Falls development, is now well under way by the Northwestern Power Company, and power is already being produced. One unit went into operation on June 3 last, another is almost ready to start and a third is scheduled for Sept. 1. Each unit has a designed capacity of 18,750 hp., but by operating under full head secured by dropping the tail race and raising the dam, production can be doubled. The initial three units, accordingly, will be able to develop 112,500 hp., or approximately one-half of the ultimate designed capacity.

INVESTIGATION of the feasibility of the huge scheme of hydro-electric development on the Dauphin River in the province of Manitoba has begun with the despatch of engineers from Winnipeg to study all angles of the proposal made by Premier Bracken before the Manitoba Legislature to divert the Saskatchewan River for power purposes. In his budget speech last February the premier outlined a plan whereby the Saskatchewan River would be diverted through Lakes Winnipegosis and Mani-

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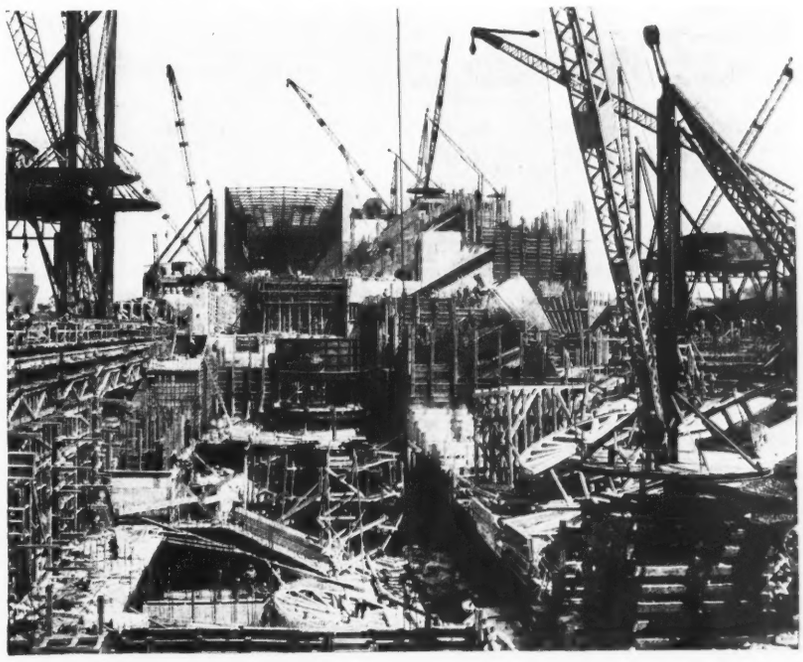
WORK PROCEEDS DESPITE INQUIRY



While parliamentary investigation of the Beauharnois Power Corporation proceeds, no time is being lost in construction work on the project, where over 2,500 men are now employed. The photograph shows progress being made on the power house under construction at Lake St. Louis end of the canal. It is being built to house ten 50,000-hp. units

toba greatly augmenting the flow in the Dauphin River where the actual power would be developed. Topographical and hydro surveys will be pushed on rapidly throughout the summer to ascertain the facts respecting the huge potential development which it is believed would generate 400,000 hp. at a point on the Dauphin River 140 miles from Winnipeg.

THE Shawinigan Water & Power Company recently released 33,000 additional horsepower at its La Gabelle plant in Quebec, bringing its total developed power resources to 863,000 hp. The company is continuing its expansion program which will increase its power production by 500,000 hp. over a period of time. Plans are under way for the pushing ahead of work on six new developments, which will take care of future demands in the section.

ARRANGEMENTS are now under way for the official opening of the Slave Falls power plant of the Winnipeg Hydro Electric Power Commission. The ceremony will take place towards the end of August, a few days before the plant goes into actual operation as a unit of the hydro system. The Slave Falls plant is designed for an ultimate capacity of eight 12,000-hp. units, two of which comprise the initial installation, soon to go in service.

German Power Output Less Due to Factory Closings

THE ADVANCE of the electric power industry in Germany suffered a severe reverse during the year 1930, according to a report received in the Department of Commerce from Acting Commercial Attaché Douglas Miller at Berlin. The monthly statistics for that year show that the production of current was approximately 1,500,000,000 kw.-hr. less than in the previous year when it had amounted to 30,600,000,000 kilowatt-hours.

Up to the end of 1929 the electric power industry was comparatively little affected by German economic conditions. This was chiefly due to the fact that the reconstruction and rationalization of German commerce and trade brought about an extensive electrification of plants which resulted in a considerable excess consumption of electric current beyond the amount that would have been seasonally justified.

The increasing electrification of German industry since 1925 can be seen from the very strong advance in the consumption capacity of commercial users of electric current. The consumption capacity of 103 electricity works covered by the monthly electricity statistics amounted to 4,600,000 kw. at the beginning of 1930 as against 3,100,000 kw. at the beginning of 1925. This corresponds to an advance of approximately 50 per cent over a period of five years.

COMING CONVENTIONS

American Society of Mechanical Engineers. Regional meeting in Kansas City, Mo., Sept. 7-9. Annual meeting in New York City, Nov. 30-Dec. 4. Secretary, Calvin W. Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. District meeting at Lake Tahoe, Calif., Aug. 25-28. District meeting at Kansas City, Mo., Oct. 22-24. Secretary, F. L. Hutchinson, 33 West 39th St., New York.

American Welding Society. Fall meeting at the Copley-Plaza Hotel, Boston, Mass., Sept. 21-25. Secretary, M. M. Kelly, 33 West 39th St., New York City.

Association of Edison Illuminating Companies. Forty-seventh annual meeting at The Greenbrier, White Sulphur Springs, W. Va., Sept. 21-25. Secretary, Preston S. Millar, 80th St. and East End Ave., New York City.

International Railway Fuel Association. Annual convention at the Hotel Sherman, Chicago, Ill., Sept. 15-16. Secretary, C. T. Winkless, Room 700, La Salle Street Station, Chicago, Ill.

National Association of Power Engineers. Annual convention and mechanical exposition in the Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago.

Southwest Power Conference and Show will be held in Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, George F. Klein, Chamber of Commerce, Kansas City, Mo.

Third International Conference on Bituminous Coal. At Carnegie Institute of Technology, Pittsburgh, Pa., Nov. 16-21. Chairman, Thomas S. Baker, president of Carnegie Institute of Technology.

Universal Craftsmen Council of Engineers. Annual convention at the Sherman Hotel, Chicago, Ill., Aug. 4-8. Secretary of Convention Committee, James J. Blaine, 7342 Harvard Ave., Chicago, Ill.

Westinghouse Official Dies

TRUMAN P. GAYLORD, vice-president of the Westinghouse Electric & Manufacturing Company, died suddenly on July 5 in Shelby, Mich., where he had been visiting his mother. He was 60 years old.

Born in the town where he died, Mr. Gaylord was graduated from the University of Michigan and Armour Institute of Technology. From 1892 to 1893 he worked as engineer of underground construction for the Chicago World's Fair, at the close of which he became assistant professor of electrical engineering at Armour Institute. He was associated with the Commonwealth Edison Company from 1898 to 1899, when he entered the employ of the Westinghouse company.

He was appointed district manager of the Westinghouse company's Chicago office in 1902, the position he occupied until he was made vice-president.

Personals

CALVIN W. RICE, secretary of the American Society of Mechanical Engineers, received an honorary award at the recent 75th anniversary meeting of the Verein deutscher Ingenieure. Others similarly honored by the V.D.I. were Prof. AXEL F. ENSTRÖM, of Sweden; R. A. VAN SANDICK, Holland; Dr. CARL SULZER-SCHMID, Switzerland; Dr. FRITZ NEUHAUS, Berlin; KARL HARTMANN and MAX KNOEVENAGEL, Hannover; JOHANNES KÖRTING and Dr. OTTO PETERSON, Düsseldorf. The award consisted of a silver plaquette engraved to commemorate the founding of the V.D.I. at Alexisbad in 1856. Dr. Rice was the official representative of the A.S.M.E. at the 75th anniversary meeting, held in Cologne.

SAMUEL D. FITZSIMMONS, for many years plant engineer with the Brown & Sharp Manufacturing Company, at Providence, R. I., has transferred his efforts to the electric utility field and is now vice-president of the Narragansett Electric Company, of Providence.

H. B. TEEGARDEN will assume the post of solicitor of the Federal Power Commission about Aug. 1. The office has been vacant since the dismissal of CHARLES A. RUSSELL last December, and his successor is a young attorney who has been associated with the anti-trust division of the Department of Justice for seven years. Mr. Teegarden brings to the power commission a wide experience with regulatory litigation, as he has been in immediate charge of cases relating to regulation under the Grain Futures Act and the Packers and Stockyards Act.

EDWARD T. MOORE, president of the Power Control Corporation and inventor of a device for governing and limiting electric power which is now in extensive use in mines in the United States, is at present in Mexico to supervise the first installation of his invention in a Mexican mine. The installation will be made in a silver mine of the El Potosi Mining Company at Chihuahua. Mr. Moore will later go to Mexico City and then to San Francisco, Los Angeles, Seattle, Salt Lake City and Arizona.

RICHARD L. BINDER, president of the Metals Coating Company of America, sailed on July 7 for a business trip to Europe. His trip is planned to establish intimate contact with important developments abroad and to gain first-hand knowledge of the opportunities afforded in Germany in view of the economic adjustment now under way.

J. W. JANTZEN, a member of the engineering staff of the Central Arizona Light & Power Company, Phoenix, since Dec. 1, 1925, has been placed in charge of the company's operations in the Glendale-Peoria district, with headquarters at Glendale.

Business Notes

LINK-BELT COMPANY, Chicago, Ill., announces that Ralph M. Hoffman, for eight years manager of the Seattle office of its Pacific division, has been appointed vice-president and sales manager of that division, with headquarters in the recently completed $500,000 plant of the company, located at 400 Paul Ave., San Francisco, Calif. Mr. Hoffman succeeds Harold H. Clark, who retired on June 1 as vice-president and assistant secretary after 30 years' service with the company and its subsidiaries.

STRONG-SCOTT MANUFACTURING COMPANY, Minneapolis, Minn., announces the appointment of the Dravo-Doyle Company as district representatives in Chicago, Ill. (Marquette Building), and in Cleveland, Ohio (4800 Prospect Avenue), for sales and service of its coal pulverizing and burning equipment.

TIMKEN ROLLER BEARING COMPANY, Canton, Ohio, announces that in accordance with the regular annual practice, its plants will be shut down from July 16 to 29 for the usual vacation.

ARMSTRONG CORK COMPANY, Lancaster, Pa., announces the consolidation of its Cincinnati branch sales offices and warehouses in one building located at 232 West 7th Street. The divisions affected and the quarters from which each will move are as follows: Armstrong Cork Company, floor sales division, 538 Dixie Terminal Building; Armstrong Cork & Insulation Company, insulation sales division, 1015 Broadway; Armstrong Cork Company, cork sales division, 1017 Broadway.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., announces the following changes in executive personnel: Alexander Taylor, assistant to the vice-president, has been assigned to duties concerned with the Pennsylvania railroad locomotive contract. This work, it is stated, will require his entire time, so general supervision of his previous activities has been delegated to H. C. Thomas, director of manufacturing stocks. E. R. Norris has been appointed assistant to the general works manager. C. G. Bunnell, formerly purchasing agent at East Pittsburgh, will now function as general purchasing agent.

KELMAN ELECTRIC & MANUFACTURING COMPANY, Los Angeles, Calif., announces the appointment of Farnham & Cunningham, M-29 Edison Building, Los Angeles, as its sales representatives for oil circuit breakers in Arizona and in San Diego, Calif.

ILLINOIS STOKER COMPANY, Alton, Ill., announces the establishment of the Illinois Stoker & Combustion Company, Ltd., Great Britain, with headquarters at 45-50 Holborn Viaduct, London, E.C. 1. Lowden Morton, formerly with the Vickers Boiler Company of England, is manager of the new company.

How's Business?

IN FACE of frightening foreign financial news and the full force of summer slackness, our index has recovered from its slight slump at the end of June to a level in line with the average of the past six months, says *The Business Week*, July 22. The steadiness of domestic securities in the home market is an encouraging sign of resistance of American psychology to panic possibilities, and the passing of the darn-fool stage of this depression.

Production of electricity by public utility companies for the week ended July 11 was 1,655,245,000 kw.-hr., or 0.3 per cent above the corresponding period of last year, according to N.E.L.A. figures. The Atlantic seaboard showed an increase of 4.6 per cent in output above last year. The central industrial region registered, as a whole, a decrease of 3.2 per cent, while the Chicago district showed a decrease of 3 per cent. The Pacific Coast showed a gain of 2.6 per cent.

Trade Catalogs

WATER-TUBE BOILERS—Details of the construction and operation of Edge Moor "Bent Tube" boilers are exceptionally well presented in a new catalog (No. 69) recently issued by the Edge Moor Iron Company, Edge Moor, Del. The catalog is fully illustrated with wash drawings, shop pictures, blueprints and photographs of actual installations.

THERMOMETERS—A complete description of the units which compose a modern recording thermometer is given in the new 40-page bulletin (No. 169) published by the Foxboro Company, Foxboro, Mass. Information is included on both the vapor-tension type and gas-filled thermometers, together with useful engineering data on bulbs, sockets, helical tubes and instrument boards.

MAGNETIC CLUTCHES—"Keeping Pace With Machine Design" is the title of a new booklet just published by Cutler-Hammer, Inc., 294 North 12th St., Milwaukee, Wis., which gives the details of construction, operation and application of C-H magnetic clutches, including a full description of the newly developed duplex clutch.

CAR SPOTTERS—A 12-page booklet, No. 1292, issued by H. W. Caldwell & Son Company, 2410 West 18th St., Chicago, Ill., describes car spotters, pointing out their important features and giving complete dimensions, capacities, horsepower of motor, speeds, etc., as well as portraying through installation photographs, the varied applications of these units. The book also shows a chart and method of figuring the degree of curvature of railroad tracks, and the pull on the car spotter rope.

PORTABLE LOADER—Folder No. 1298 issued by the Link-Belt Company, Philadelphia, Pa., describes the recreated, advanced type of "Cub" loader now equipped with roller-bearing idlers, ball-bearing wheels for easy shifting, ball-bearing motor, improved raising and lowering device, and a number of other features.

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Fuel Prices

FUEL OIL

Boston—July 14, tank-car lots, f.o.b. 12@14 deg. Baumé, 2.9c. per gal.; 28@32 deg., 4.83c. per gal.

New York—July 16, f.o.b. Bayonne, N. J., 28@34 deg. Baumé, industrial use, tank-car lots, 4c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 5c. per gal.

Philadelphia—July 15, No. 3, industrial gas oil, $1.83 per bbl.; No. 4, light industrial fuel oil, $1.31 per bbl.; No. 5, medium industrial fuel oil, $1.20 per bbl.; No. 6, heavy (Bunker C), $1.05 per bbl.

Pittsburgh—July 8, f.o.b. local refinery, fuel oil, 30@34 deg., 2.25c.@2.75c. per gal.; 36@40 deg., 2.25c.@2.725c. per gal.

Cincinnati—July 7, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4.5c. per gal.; 26@30 deg., 4.75c. per gal.; 30@32 deg., 5c. per gal.

Chicago—July 11, tank-car lots, f.o.b. Oklahoma; freight to Chicago, 90c. per bbl. or 42 gal.; 18@22 deg., 22.5c. per bbl.; 22@24 deg., 25c. per bbl.; 24@26 deg., 27.5c. per bbl.; 26@28 deg., 32.5 per bbl.; 28@30 deg., 37.5 per bbl.

St. Louis—July 7, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.02 per bbl., or 42 gal.; 26@28 deg., $1.095 per bbl.; 28@30 deg., $1.117 per bbl.; 30@32 deg., $1.275 per bbl.; 32@36 deg., gas oil, 2.526c. per gal.; 38@40 deg., distillate, 3.026c. per gal.

Dallas—July 11, f.o.b. local refinery 24@26 deg., 70c. per bbl. or 42 gallons.

COAL

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Pool 9, super low-vol.	New York	$1.65 @ $1.80
Pool 10, h. gr. low-vol.	New York	1.50 @ 1.65
Pool 11, low-vol.	New York	1.40 @ 1.50
Smokeless, mine-run	Chicago	1.50 @ 1.75
Smokeless, slack	Chicago	.50 @ 1.00
Harlan, Ky., slack	Chicago	.85 @ 1.10
Franklin, Ill., mine-run	Chicago	2.15
Franklin, Ill., screen	Chicago	1.10 @ 1.75
Ind. 5th Vein, m.-r.	Chicago	1.20 @ 1.75
Standard Ill., mine-run	St. Louis	1.25 @ 1.40
W. Ky., mine-run	Louisville	.85 @ 1.10
W. Ky., slack	Louisville	.60 @ .75
Pittsburgh, mine-run	Pittsburgh	1.35 @ 1.45
Smokeless, mine-run	Cincinnati	1.65 @ 1.75
Smokeless, slack	Cincinnati	.75 @ 1.25
Kanawha, mine-run	Cincinnati	1.00 @ 1.35
Kanawha, nut-slack	Cincinnati	.40 @ .85
Anthracite (Net Tons)	**At Mine, for Shipment to**	**Price per Ton**
Buckwheat	New York	$3.10 @ $3.25
Barley	New York	.90 @ 1.40

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ark., Hot Springs—Arkansas Power & Light Co., c/o C. J. Griffith, Vice-Pres., Little Rock, preliminary plans for hydro-electric power development on the Ouachita River about 24 mi. above Carpenter Dam near Hot Springs. Maturity indefinite. Estimated cost $10,000,000. Engineer not announced.

Calif., Long Beach—City plans construction of 3 story public utilities building. Estimated cost $150,000. Architect not selected.

Calif., San Francisco—City and County of San Francisco, making plans for constructing steel trolley ways, installing hoists and compressor units.

Calif., San Francisco—City and County of San Francisco, to vote on $1,000,000 bonds in November for construction of a power house at Red Mountain Bar in connection with Hetch Hetchy Water System. M. M. O'Shaughnessy is city engineer.

Conn., Hartford — Engineering Dept., City Hall, awarded contract for the construction of a pumping station, also flood protection in Dyke project, to C. W. Blakeslee & Sons Inc., 58 Waverly St., New Haven, $82,374.

Conn., Middlefield—Lyman Farms, J. Lyman, Mgr., awarded contract for construction of a fruit cold storage plant at Lymans Farms, to C. F. Wooding Co., Wallace Ave., Wallingford. Estimated cost $45,000.

Conn., Newton—Fairfield State Hospital Commission, N. G. Osborn, Old Senate Chamber, State House, Hartford, awarded contract for the construction of a group of buildings, including nurses' home, hospital, etc., on Mile Hill, to H. Wales Lines Co., 134 State St., Meriden, $1,388,736.

Conn., Southington—Lake View Farm, H. Rogers, Mgr., awarded contract for construction of a 68 x 95 ft. fruit cold storage plant to Hayes Constr. Co., 1285 East St., New Britain. Estimated cost $40,000.

Ill., Chicago—Cook Co. Comrs., County Bldg., will receive bids until July 27, for construction of 17 story, 202 x 162 ft. nurses' home on Polk St. Estimated cost $2,350,000. E. E. Hall, 123 W. Madison St., is architect.

Ind., Crown Point—City plans construction of a diesel type plant for street lighting. Burns & McDonnell Eng. Co., 400 Interstate Bldg., Kansas City, Mo., is engineer.

Ind., Ft. Wayne—City having plans prepared for waterworks improvement program to include filtration and pumping station, dam and low service pumping station, low service and high service pumping equipment, chemical handling equipment and feeding machines. Hoad, Decker, Shoecraft & Drury, Engineering Bldg., Detroit, Mich., are engineers.

Ia., Toledo—Iowa Railway & Light Corp., Security Bldg., Cedar Rapids, awarded contract for power plant, near Toledo to J. W. Hopp Constr. Co., Grunby Bldg., Cedar Rapids. Estimated cost $40,000.

Kan., Fredonia—City, A. D. Crooks, Mayor, awarded contract for construction of 47 x 50 ft. light plant to Universal Construction Co., Coffeyville, $15,440: switchboard equipment to Westinghouse Electric & Mfg. Co., 411 North 7th St., St. Louis, Mo.

Kan., Ft. Leavenworth—U. S. Army, Capt. L. G. Geron, Constructing Quartermaster, will receive bids until July 29 for hangars and boiler house. Estimated cost $33,700.

Kan., Ft. Riley—U. S. Army, Capt. R. A. Blair, Constructing Quartermaster, will receive bids until July 29, for hangers and boiler house.

Mass., Braintree — F. A. Barker, Tremont Bldg., Boston, Engr., is taking bids for waterworks pumping station for town. Estimated cost $15,000 to $20,000.

Mass., Cambridge — City having preliminary plans made for filter plant addition to waterworks pumping station and new 12,000,000 g.p.d. pumping station. Estimated cost $100,000. Fuller & Everett, 25 West 43rd St., New York, are engineers.

Mass., Gardner—Dept. Mental Diseases, State House, Boston, taking bids for heating plant in hospital at State Colony here. Estimated cost $150,000. A. B. Franklin, Inc., 25 Haverhill St., Boston, is engineer.

Mich., Crystal Falls — City, J. H. Sanders, City Mgr., has retained Holland, Ackerman & Holland, Chicago, Ill., Consult. Engrs., to prepare plans for power dam to replace present one at city power plant. Estimated cost $30,000.

Minn., Willmar—State Comn. of Administration & Finance, Capitol, St. Paul, will receive bids until July 28, for group of buildings, including 32 x 50 ft. power house addition. Long & Thorshor, 1028 Andrus Bldg., Minneapolis, are architects.

Mo., St. Louis—Water Dept., L. Day, Comr., soon take bids for reconstruction of and equipment for boiler house at Chain of Rocks waterworks pumping station on Mississippi River. Estimated cost $400,000.

Mo., Springfield—Bureau of Federal Prisons, c/o S. Bates, Supervisor, will take bids about September for hospital group for mental delinquents. Estimated cost $2,500,000. J. A. Wetmore, acting supervising architect, c/o U. S. Treas. Dept., Wash., D. C., and Jeanes & Marlow, 420 Lexington Ave., New York, are architects.

N. J., Hackensack — Bd. Freeholders, Court House, Hackensack, receiving bids until Aug. 3, for central heating plant on Hudson St. Estimated cost $40,000. Tilton, Schwanede & Githens, 420 Lexington Ave., New York, are architects.

N. J., Jersey City—Bd. Chosen Freeholders, Court House, Jersey City, will take bids about Sept. 15, for construction of 16 story, 200 x 225 ft. hall of records adjoining court house. Estimated cost $2,000,000. J. T. Rowland, Jr., 30 Veterans Sq., Jersey City, is architect.

N. Y., Brooklyn—L. I. Storage Warehouse, Inc., Nostrand and Gates Aves., plans construction of an 84 x 130 ft. ice skating rink on Coney Island Ave. and Ocean Parkway. Estimated cost $150,000. H. G. Wiseman, 33 West 42nd St., New York, is architect. Maturity about December.

Okla., Hominy—City, G. H. Blackwood, clk., postponed construction of power plant building and equipment pending approval of bond issue. Estimated cost $150,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, are engineers.

Okla., Vinita—City, C. O. Wattenbarger, clk., abandoned plans for construction of light and power plant and distribution system. Franchise to Independent Power & Light Co. defeated at election Apr. 21.

R. I., Providence—Dept. of Public Works, City Hall, awarded contract for the construction of a booster pump house on Reservoir Ave., to Central Engineering & Construction Co., 210 Main St., Pawtucket, R. I.

Tex., Corpus Christi—City, T. Koester, city secy., will receive bids until Aug. 10 for rehabilitation of dam on Lake Lovenskiold near La Fruta. Mechanical equipment incl. 5 taintor gates 20 x 35 ft. and two 7 x 7 ft. sluice gates, electrically operated; one 7 x 7 ft. butterfly valve and two 48 in. gate valves. Estimated cost $475,000.

Tex., Ft. Worth—U. S. Treas. Dept., Washington, D. C., awarded general contract for construction of a 2 story, 311 x 269 ft. post office on Lancaster St., to Ralph Sollitt & Sons Constr. Co., 2543 South Michigan Ave., Chicago, Ill. Estimated cost $1,245,000.

Wash., Seattle—Mountain Lakes Water Co., J. D. Bird, Pres., 10107 Woodland Park Ave., awarded contract for construction of a diversion dam, storage reservoir, pipe lines, and complete equipment for initial unit of water system to supply territory betwen Everett and Seattle, to Ulen Engineering Corp., Lebanon, Ind., and 120 Broadway, New York. Estimated cost $2,000,000.

W. Va., Grantsville—Recorder of town will receive bids until Aug. 11, for construction of a small filter plant to include low and high lift pumps. J. P. Blundon, Consult. Engr., Law Bldg., Keyser, is engineer.

Wis., Milwaukee—Plankington Packing Co., Muskego Ave. and Canal St., awarded contract for construction of 5 story, 138 x 183 x 89 ft. cooler building to Hinzengee Constr. Co., 424 East Wells St., Milwaukee. Estimated cost $500,000.

Alta., Calgary—Calgary Power Co., plans construction of storage dam on Upper Kananasakis River. Estimated cost $100,000.

Equipment Wanted

Pump, Generator Plant, etc.—Los Angeles, Calif.—Bd. Comrs. Los Angeles Co., soon takes bids for equipment for Big Tujunga Dam 1: pump and motor complete, one 10 kva. gasoline driven generator plant, automatic transfer switch, electrical equipment, flood lights, insulators, conduits, etc.

Pumping Plant—Merced, Calif.—City plans to drill well and install pumping plant at Bear Creek Park. Estimated cost $1,400.

Boilers, Pump, etc.—Muncie, Ind.—Bids will be received by Board of Commissioners of Delaware County until Aug. 1, for furnishing and installing boilers, breaching, piping, condensation pump, furnace stoker, etc. W. Max Shafer is auditor.

Coal and Ash Handling Equipment—Wyandotte, Mich.—Froehlivk & Emery, Second Natl. Bank Bldg., Toledo, Engrs., will receive bids until Aug. 3, for furnishing and installing coal and ash handling equipment for new power house on Vinewood Ave. and Van Alstyne Blvd., to include elevators, conveyors, motors, etc.

Pumping Units — Yakima, Wash. — Bu Reclamation, U. S. Custom House, Denver, Colo., will receive bids until Aug. 17 for two pumping units for Wippel pumping plant, Kittitas Div., Yakima Project.

Engines—Cairo, Egypt—Department of Public Works, Mechanical Branch, will receive bids until Sept. 1, for four 150 hp. marine diesel engines, gear and all accessories, for coal barges.

Generator, Motor Generator, etc. — Cairo, Egypt—Ministry of Interior will receive bids until Sept. 2, furnishing and erecting at Delta Barrage Spinning factory, A.C. generator of 125 kva. with exciter on same shaft, also motor generator set for charging existing accumulator of 120 cells, 300 amp. hrs., and vertical Diesel engine to drive same.

Industrial Projects

Ill., Bellwood (Chicago P. O.) — Jefferson Electric Co., 15th and Laflin Sts., Chicago, will soon award the contract for a plant at Madison Ave. and 25th St. Estimated cost $550,000. Olsen & Urbam, 228 N. La Salle St., Chicago, are architects.

N. C., Durham—Southern Creosoting Co. is planning to construct a plant on Hillsboro Road for creosoting railroad ties, piles, poles and other timbers. Estimated cost $150,000.

B. C., Port Renfrew—Lone Star Timber, Lumber & Pulp Co., Pioneer Drug Co. Bldg., Seattle, Wash., B. A. Grover, Pres., plans to construct a pulp mill, sawmill, shingle mill and veneer plant on Vancouver Island, here. Estimated cost between $6,000,000 and $8,000,000.

Ont., Kitchener—Norton Drink Co., King St. E., is having plans prepared for 2 story brick bottling plant. C. H. Norton is owner.

Que., Three Rivers—Canadian Industries, Ltd., Hamilton, Ont., plans to construct a plant here for the manufacture of cellophane. Estimated cost $1,500,000.

Okla., Tulsa—Texas Salt Products Co., R. L. Drake, Vice-Pres. and Gen. Mgr., 135 East 42nd St., New York, N. Y., is building a salt plant at West 35th St. and Sapulpa Rd., West Tulsa, by day labor. Estimated cost $800,000.

Okla., Sand Springs—Commander Mills, Inc., c/o H. B. Howell, Supt., has awarded the contract for a 2 story, 57 x 107 ft. cotton bleaching plant to E. R. Grimshaw, Philcade Bldg., Tulsa. Estimated cost $100,000. Contract for filtration equipment let to Roberts Filter Co., Darby, Pa., pumps and motors, to Allis Chalmers Co., Milwaukee, Wis.

Penn., Donora — Gulf Refining Co., Frick Bldg., Pittsburgh, will soon award the contract for an oil distributing plant, including water terminal, on the Monongahela River. Estimated cost $100,000.

Penn., Pittsburgh—Pittsburgh Cut Stone Co., 5116 Cypress St., is having plans prepared and soon takes bids for a 1 story, 175 x 200 ft. stone cutting plant on Preble Ave. Hunting, Davis & Dunnells, Century Bldg., are architects.

Tex., Mineola—Everybody's Independent Refining Co., c/o R. J. Worthington, Mineola, plans to construct a refinery 2½ miles from here to have daily capacity of 2,500 bbl. Contract will soon be let.

Tex., San Angelo—Joseph Sanger, San Angelo, purchased refinery at Pioneer, near here, and will install new equipment to cost $90,000.